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# **STREET CUTS IN CITY AND COUNTY STREETS**

**By**

**James M. Iddins**

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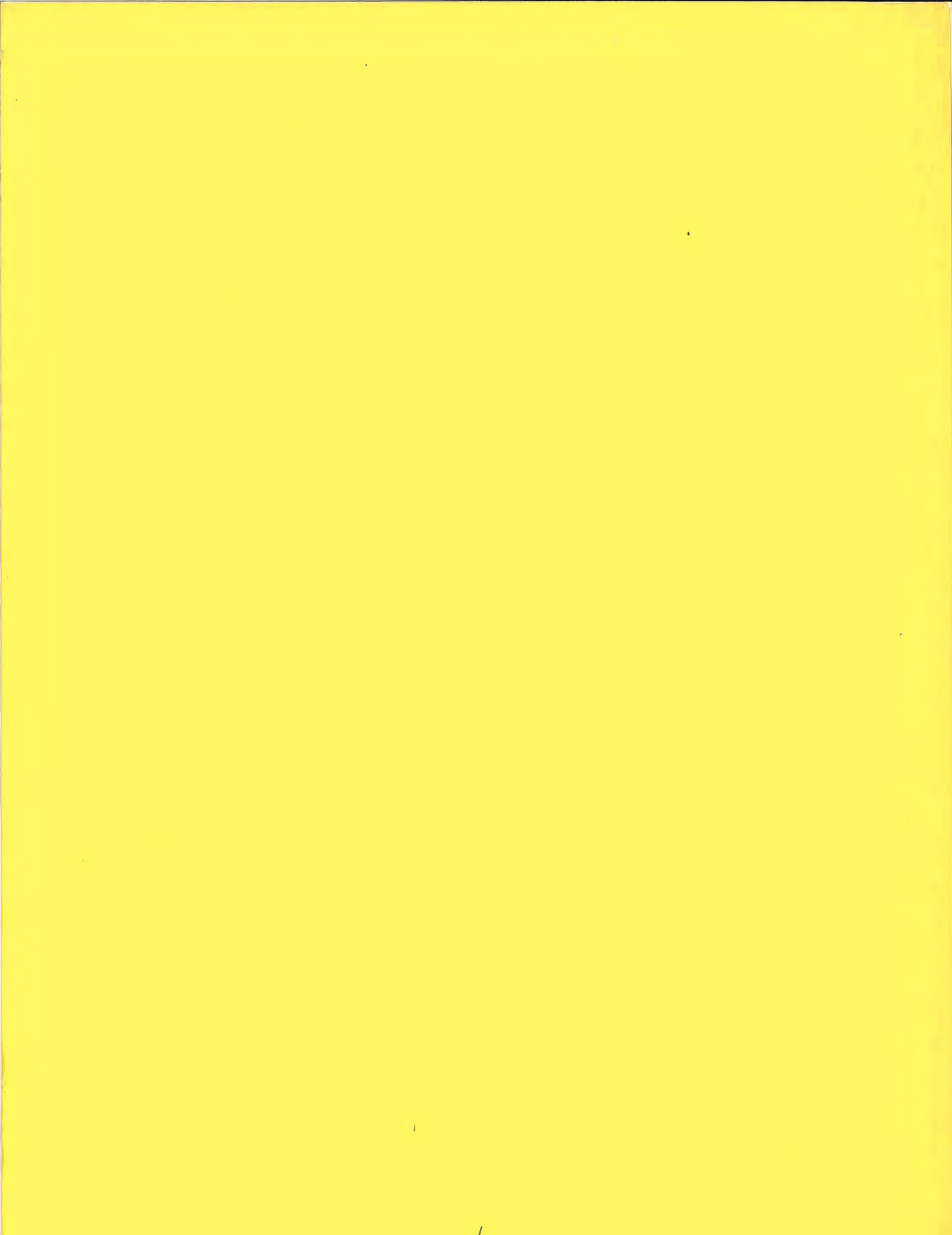
**In cooperation with**

**INDIANA DEPARTMENT OF HIGHWAYS**

**INDIANA ASSOCIATION OF COUNTY COMMISSIONERS**

**INDIANA ASSOCIATION OF CITIES AND TOWNS**

**FEDERAL HIGHWAY ADMINISTRATION**



STREET CUTS  
IN  
COUNTY & CITY STREETS

A Report  
Prepared for The  
Highway Extension and Research Project  
for Indiana Counties and Cities

by  
James Mabry Iddins

August 1983

This report was a thesis in partial  
fulfillment of the requirements for the degree  
of Master of Science in Civil Engineering

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## LIST OF SYMBOLS

T.L.	=	Taper Length
mph	=	Miles Per Hour
FT.	=	Foot or Feet
'	=	Foot or Feet
in.	=	Inch
"	=	Inch
Mg	=	Milligram
m	=	Meter
D	=	Diameter
MC	=	Moisture Content
S	=	Saturation
W	=	Water Content
Pw	=	Density of Water
Ps	=	Density of Solids
Pd	=	Dry Density
CDF	=	Control Density Fill
RC	=	Relative Compaction

## ABSTRACT

Iddins, James Mabry. M.S.C.E., Purdue University, August 1983. Street Cuts in City and County Streets. Co-Major Professors: Dr. Charles F. Scholer and Dr. Donn E. Hancher.

This thesis presents a detailed study of the methods and procedures used by county and city engineers to control street cuts. The report addresses all phases of a street cut program. The items addressed are codes and specifications, testing and inspection, traffic control, stabilization and compaction, how to make repairs and alternatives to street cuts. State, county, city and utility company officials were consulted on their present street cut programs. From reviewing these programs, certain methods and procedures are recommended in this report for county and city engineers to update or round out their existing programs. Usually several alternative methods will be presented so local officials can select the method or procedure which best meets their needs.

## CHAPTER I

### INTRODUCTION

The conditions of our city and county streets are of increasing interest to the motoring public. The public is paying more in the way of fuel tax, but receiving less in terms of smooth riding quality roads. In fact, the rough riding surface causes the motoring and bicycling public to spend thousands of dollars each year for front end alignments and other repair work on their automobiles and bikes. The public is turning to their local city and county engineers and wanting answers about the poor road conditions.

Even with increased fuel taxes, city and county engineers must run their offices with low budgets and few personnel. The reason for this is that the majority of local public agencies budget increases must go to salary increases. Therefore, actual working funds remain at low levels. The low budgets cause city and county engineers to cut back on important programs, like street cut repair control. Street cuts are becoming a major problem because utility contractors are not being controlled very well by

most utility, city and county engineers. The contractors have taken advantage of the lack of control by repairing the street cuts improperly. As a result of this practice, many street cut repairs fail.

Street cuts are made by a variety of organizations. Some utilities make their own street cuts while most large utilities subcontract their repairs to local general contractors. Many cities own utilities, such as a water company. The Public Works Departments in these cities will handle all street cuts for the city owned utilities. Plumbers may be contacted by homeowners to connect their homes to city water mains. Thus, plumbers are even involved in making street cuts. No matter who owns the utilities or who does the work, the same standards should apply. During the rest of this document, contractors, plumbers and utilities making street cuts will be referred to as "utility contractors."

The purpose of this thesis is not to have every city and county rewrite and reorganize their entire street cut programs. This thesis was written to show the methods which work well for several states, counties and cities. Then cities and counties with incomplete programs, can improve or round out their programs. This thesis should not be used as specifications, but as a guide to develop a set of specifications and procedures. The research for this thesis was conducted through personal interviews, telephone calls and

letters to state, county, city and utility engineers. States were contacted because cities and counties usually develop their material from state specifications. The State Highway Departments or Departments of Transportation of Indiana, Kentucky, Tennessee, Michigan, Illinois and Ohio were contacted. The city engineers of Indianapolis, Valparaiso, Kendallville, West Lafayette, Lafayette, Bedford, and Alexandria were contacted. Only one county engineer was contacted. This was because the largest volume of street cuts are made in cities.

When procedures and specifications are presented in the following chapters, usually two methods are presented. Then a specific procedure or specification is recommended. The city or county engineer should select the procedure or specification which best fits his need.

## CHAPTER II

### SPECIFICATIONS AND PROCEDURES

Procedures that utility contractors should follow for making road cuts have been developed by most cities and counties within Indiana. These procedures vary greatly from city to city or county to county. This chapter is designed to aid cities and counties in the development of or in the improvement of specific procedures. The whole object is to provide citizens the most service for their tax dollars. These guidelines were developed by consultation with several state highway departments and county and city engineers.

The main points of detailed policies and procedures are listed below. Afterwards a brief discussion is given of each.

- Performance Bond
- Permit
- Specifications
- Inspection Procedures
- Emergency Procedure
- Penalties

## Performance Bonds

Surety (performance) bonds should be required for utility work and occupancy on city or county roads. The bonds are intended primarily to guarantee prompt and satisfactory replacement and repair, of facilities that may be damaged or disrupted by the utility contractor's operations. The amount of the performance bond varies among local governments. One method is to set a flat rate, a minimum of \$2,500 (1981 figure). The other method is to have the monetary value of the bond based on the potential for road damages.

The bond should remain in force until the work complies with standards and all permit matters are complete to the satisfaction of the Engineer (inspector). The normal period to hold a performance bond is one to two years. The bond should not be released until the repair is reinspected. The release of the performance bond will be discussed further under the inspection section of this chapter. Examples of standard performance bonds are presented in Appendix 1A. Most cities consulted have the utilities maintain a standing performance bond. Therefore, one is not needed for each utility cut made. [1]

## Permits

Most highway and street departments do require a permit by utility contractors to allow them to make roadway cuts. The variations of procedures for permits vary greatly with



the agencies consulted.

Permit costs of the states consulted seem to range from no charge to \$40.00. States with no-charge permits usually bill the utility contractor separately for inspection services. The permit cost is usually charged per 500 feet of road. Therefore, under the flat \$40 system, a utility trench 1000 feet long would cost \$80. The 40 dollar permit fee usually takes care of inspection services. A combination of both methods seems well adapted for city use. A small 5-10 dollar handling fee and a later bill for the amount of inspection services performed is recommended. The amount charged should be stated in with the procedures and specifications. The cost for inspection should be charged per trip and not per hour. A fair charge would be 10 to 15 dollars per visit.

States require utility contractors to submit a copy of their work plans for street cuts. The states review the plans to ensure standards and specifications are being met. Cities usually do not require the submittal of plans. They only require that the pavement be replaced in "as good or better than original condition." This seems reasonable, because cities do not have the work force that the states have, to check all the permit plans. This is where specifications are important. They will be discussed in more detail in the next section.

Utility contractors have time schedules as well as any business. Therefore, being able to forecast a project's duration is important, including the time to obtain a permit. The time duration for permit approval should be well defined for the contractors. Time durations for cities or counties will be much less than for states since plans usually do not have to be reviewed. A complete schedule by work days would be helpful for the utility contractors. An example of a time table is presented in Appendix 4A. Procedures for emergency cuts will be discussed later in this chapter.

#### Specifications

The phrase "replaced in as good or better than original condition" is no substitute for an up-to-date set of specifications. Specifications are essential to quality street cut repairs. All states consulted have specifications, while very few cities and counties do. The specifications should be used by inspectors during their inspection of the repair. Specifications help to ensure that the essential features for proper street repair are upheld. The features are (a) the integrity of the pavement structure, shoulders, and embankment slope; (b) restoration of the structural integrity of the entrenched roadbed; (c) security of the pipe against deformation likely to cause leakage; (d) assurance against the trench becoming a drainage channel; and (e) assurance against drainage being blocked by the

backfill. These are all important points which the specifications and inspectors are there to protect.

Some utilities may have alternate specifications that they prefer to use. It is a good policy to let the utility use its own specifications, if it meets minimum standards. The specifications should be reviewed by the city or county engineer. Furthermore, it is important to maintain a good working relationship between the engineer and the utility. The recommended specifications are presented in Chapter VII.

#### Inspection Procedures

The inspection phase of street cuts is important to the quality of the finished product. It is a consensus that the street cut restoration done within any Indiana city or county will be no better than the inspection effort put forth by the Permit Office and other city agencies. In addition, the Permit Office must have enforcement mechanisms available for dealing with contractors who do not obtain permits or who perform work in violation of city codes, specifications or policies. Therefore, all street cuts should be inspected. It is recognized that most cities and counties do not have the manpower to furnish a thorough inspection program. Somewhere in the policies and procedure it should be stated:

That any inspection by the city or county shall in no way relieve the utility owner of any duty or responsibility to the general public nor shall such services and/or control by the city or county relieve the utility owner from any liability for loss, damage or injury

to persons or adjacent properties. [16]

If large projects require constant surveillance, then an inspector should be assigned to the project.

The inspector should make sure all repairs are made in accordance with stated specifications and codes. Failure to install facilities in accordance with these policies should result in immediate action. The inspector should advise the utility contractor to suspend further construction activities at that site until corrective measures have been made to the satisfaction of the city or county. The Indiana State Highway Inspection Form is in Appendix 3A. [16]

A good policy is to have the utility contractor call the Engineer's office 24 hours before the cut is to be made. This gives the city or county time to schedule an inspector to the repair. Some cities and counties require a call when the firm is ready to backfill. This may impede the work, but it should greatly increase the quality of the street repairs. [4]

The immediate inspection is important, but continual surveillance for settlement or failure can also improve quality. Procedures for failure or settlement will be discussed in a later section. One idea that some states impose on utilities is paint markings on the repaired surface. The Indiana State Highway Department uses the national color code listed below.

1) Safety Yellow	Gas Company
2) Safety Orange	Telephone Company
3) Safety Blue	Water Company
4) Safety Red	Electric Company
5) Safety Green	Sanitary District
6) Safety Gray	Oil Line
7) Safety White	Stream Line
8) Safety Pink	Television Company

The above colors are used to paint a 2" x 4" rectangular patch on the curb side to identify the cut (or a 3" diameter disc at the leading edge). This paint should be maintained by the utility for a period of one year after the repair is made. This way the local agency can immediately tell which utility is responsible for the settlement or failure. [4]

#### Emergency Procedures

Sometimes emergencies arise, especially with gas and water utilities, which demand repairs immediately. Therefore, the city or county engineer should have set procedures, with which utilities are familiar in order to handle these situations. A good policy, which seems to work well for several cities, counties and states, is to require the utilities to notify the permit office by phone. At night, there should be a designated person to handle the call so that the utility could be issued a permit number. The permit number allows the company to begin work

immediately. The utility must then come into the Permit Office the next day and complete the permit application and pay the fee.

#### Penalties for Non-Compliance

There are good relations generally between the local governments and utility companies. The most effective enforcement mechanism, for a contractor caught in the act of doing work without a proper permit is the issuance of an ordinance violation ticket by an inspector or the Police Department. Consideration should be given to raising the minimum fines for such code and ordinance violations. Forwarding copies of letters detailing problems relating to a particular company to the Better Business Bureau has proven to be an effective mechanism for obtaining compliance with city codes, requirements, procedures, and policies. [4]

When settlement of a street cut occurs, it is important to have an established policy to handle these situations. The method recommended is, if it does not endanger the public, to notify the utility to make the repairs. A specific time period should be designated, like two weeks. Then if the repairs are not made in this period, city or county forces should make the repairs and bill the utility. The utility contractor should not be issued any more permits until its current bill is paid. If the utility contractor refuses, the bonding company should be notified. This policy would not work for utility companies. Limiting them access

to the right-of-way would only hurt the customers. Therefore, in the case of utility companies, if the initial fine is not paid in two weeks it should be doubled or some similar procedure. The county and city engineers should have an agreement on this policy with utility companies. It should be stressed that good relations and communications with utilities can prevent situations like the one described above.

In addition to all these recommended policies and procedures, it is important to communicate with utilities. These specific policies and procedures do not have to be established by all local governments. The local agencies should evaluate their present street cut procedures and incorporate the policies and procedures listed within this document which will help them round out their present policies and procedures. As was stated earlier, the object is to furnish the public with the best service possible.

### CHAPTER III

#### TESTING

The only way to ensure quality street cuts is through a thorough program of inspection and testing. This section of the chapter will be geared toward the various testing methods which are practical for cities and counties to use in testing base material compaction, of street cuts. Most cities and counties will not have the manpower to do their own testing. Therefore, one method to develop a testing program is to call in a consultant. Several testing firms were consulted in the Indianapolis area for prices. It must be emphasized that every utility repair does not have to be tested. It is recommended that the consultant, if hired, should work 4 to 8 hours per week. The consultants consulted said the charge for this would be \$60.00/4 hours or \$120.00/8 hours (May 1983). Three tests could be made per hour. This should be plenty of tests for a county or town. The price is reasonable if it helps reduce street cut settlement. Working with local consultants gives the Engineer's office considerable flexibility. The consultant furnishes the equipment and manpower, then when funds start running low, the testing can be stopped. [5]



For counties and cities that wish to do their own testing there are basically two types of tests, destructive and non-destructive. The destructive tests disturb already compacted material. Non-destructive tests can determine density without disturbing the compacted material. The non-destructive tests are preferable, but costs can be prohibitive. This statement is directed toward the nuclear testing. Although the initial cost is high, it is a valuable method because of its speed and accuracy. Therefore, it has been included in this thesis.

Most cities and counties do not have the funds available for modern nuclear testing so several methods are presented. The inexpensive methods recommended are the Sand Cone and the Clegg Impact Tester. These two tests can be used with state standard base materials to develop standard compaction methods. The Clegg Impact tester can then be used to field check the compaction.

No matter which means of testing is selected, the testing will enable the inspectors to see if the utility contractors are meeting compaction standards. If they are not meeting standards, penalties must be established. Most utility contractors will not change their procedures until fines are issued. Once they have to pay a few fines you should see some definite improvements. A testing program with penalties for non-compliance should encourage utility contractors to do a better job the first time around. [2]

## Sampling Method

There are two sampling methods described in this manual. They are the Sand Cone test and the Balloon Densometer test. These tests are considered destructive tests because they disturb material that has already been compacted. A test hole must be prepared to perform these tests. Care must be taken not to overexcavate. The two devices must be able to span the top of the test hole. The dry mass of the soil removed and the volume of the hole are measured. The dry density equals the dry mass divided by the volume of the test hole. The Sand Cone and Balloon Densometer are used for determining volumes of the test holes. For the standard reference to the tests see ASTM (American Society for Testing Materials) D1556 for the Sand Cone and ASTM D2167 for the Balloon Densometer test.

## Sand Cone Method

The Sand Cone Method makes use of a uniform, medium sand that has an essentially constant loose density when poured into a hole from the sand cone apparatus. Initially the mass of the sand container with the attached cone is determined. The apparatus is then placed over the hole described earlier. The valve on the sand cone container is opened, to allow the sand to flow into the hole and cone. Once the flow of sand stops, the valve is closed and the mass of the container and sand are measured. The difference from the initial mass is the mass required to fill the hole

and the cone. Since the volume in the cone is constant, the amount in the test hole can be calculated. The volume of the hole can be calculated, because the loose density of the sand is known. Figure 3.1 is a picture of a sand cone with the test plate. Appendix 1B is a sample calculation using the sand cone.

#### Balloon Densometer

This is a quick method for finding the volume of a test hole. The balloon apparatus is placed over the test hole described earlier. The bulb is pumped which forces a liquid-filled balloon into the test hole. The balloon allows the fluid to fill all the cavities in the test hole. The volume of fluid required to fill the test hole is read from the scale on the densometer. Figure 3.2 is a picture of the balloon densometer. Appendix 2B is a sample calculation using the balloon densometer.

#### Nuclear Testing

The duration of street cut repairs is very short. Some crews can make several repairs in a single day. This includes cutting the pavement exposing the utility, repairing, backfilling, compacting and repaving. This short term operation calls for a quick test to determine density and moisture content to ensure quality repairs. The test has to be quick because time is important when men and equipment are awaiting the results of the test.



FIGURE 3.1      SAND CONE AND TEST PLATE



FIGURE 3.2      BALLOON DENSOMETER

Nuclear testing is becoming more popular, even though the equipment is much more expensive. The nuclear test only takes one minute after calibration and surface preparation. The results are available immediately and are accurate if calibrated curves are used. [10]

A typical nuclear moisture-density gauge emits gamma rays from a source in the bottom of the index rod. Some of the rays (photons) are absorbed, while other rays reach the detector at the front of the gauge. The rays counted by the detector are used to determine the soil's density. There are three positions for the use of the nuclear gauge a) direct transmission b) backscatter and c) air gap. The direct transmission method is the most accurate of the three methods. ASTM D2922 gives the details on the three methods of nuclear testing. Figure 3.3 shows the three methods.

Moisture content is determined by the use of alpha particles. The hydrogen atoms in the water scatter neutrons from the the alpha particles. In this way the amount of moisture in the soil can be measured. [1]

A nuclear testing device not only has a high initial cost, but also the U.S. Nuclear Regulatory Commission requires users to have a license before they can purchase a gauge. Also, users must maintain monitoring equipment on all personnel operating the gauges. A detailed description of procedures and handling operations may be found in the

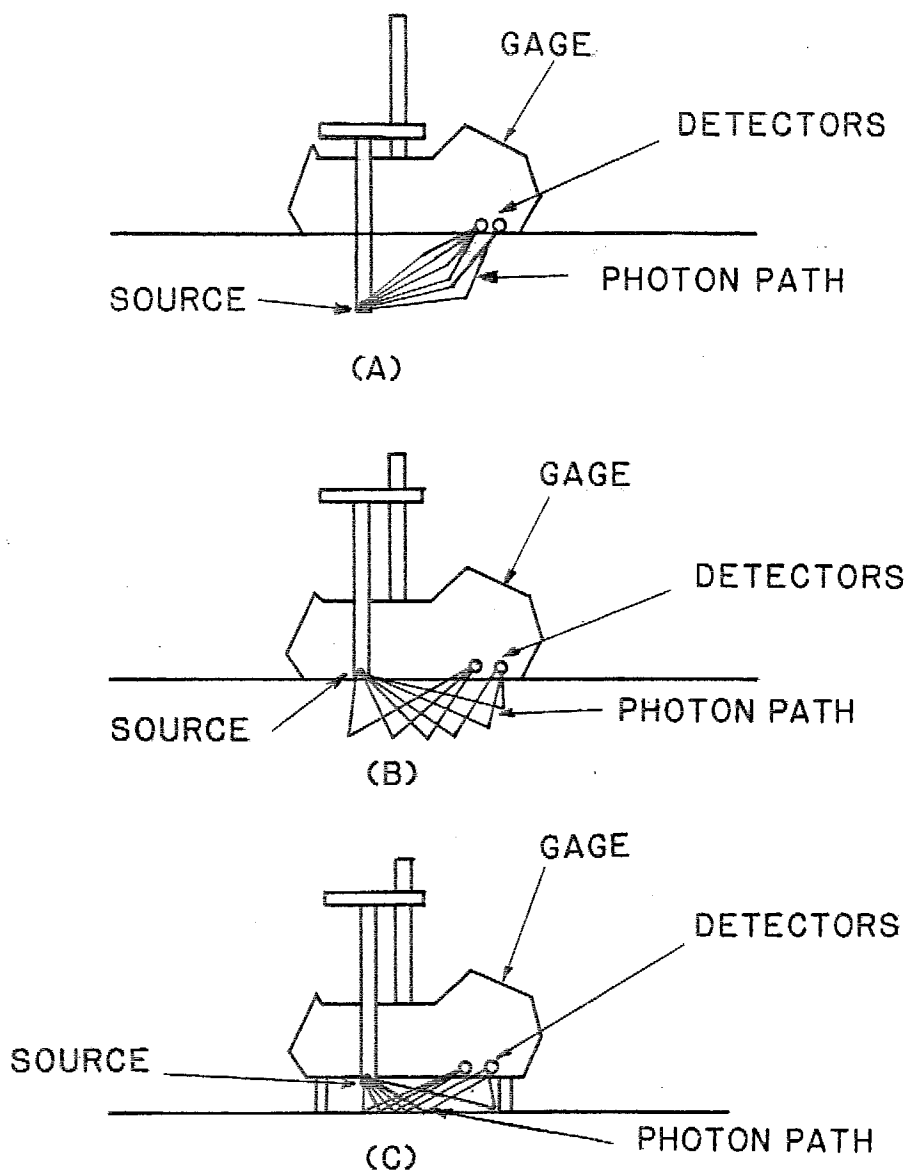


FIGURE 3.3 NUCLEAR DENSITY AND WATER  
CONTENT DETERMINATION: (a) DIRECT  
TRANSMISSION, (b) BACKSCATTER,  
(c) AIR GAP (7)

Indiana State Highway Department's "Manual for the Use of Nuclear Gauges to Determine Field Density and Moisture of Construction Materials."

#### Testing (Clegg Impact Tester)

The Clegg Impact Tester is a new device which is used to check base materials. The Clegg Impact Tester was developed by Dr. Baden Clegg, University of Western Australia. It is a non-destructive test, which consists of a 10 lb. steel hammer, a piezoelastic accelerometer, a guide tube and a hand-held meter. When the hammer is dropped, the peak output from the accelerometer registers on the hand-held meter. Usually several readings in one spot are taken until a constant value is obtained. This test is quick, simple, portable, and relatively inexpensive to use. [6]

The Clegg Impact Tester will be a valuable tool in utility construction. The Clegg Tester does not give a moisture content or a density value. It simply compares the impact value of the tested material to a standard. Most utility contractors from smaller towns do not replace the excavated material with granular fill. This will be discussed in detail in the repair chapter. Therefore, the excavated material is replaced in the repair. The best standard for a street cut repair, of this type, is the area of the repair before excavation. The standard can be set by stopping every 3-6 inches during excavation, then an impact reading can be taken with the Clegg Tester. Once the



standard has been established, the compaction of the backfill can be easily checked against the standard, to ensure adequate compaction. The backfill should be checked every 3-6 inches. Figure 3.4 is a picture of the Clegg Impact Tester. The Clegg Impact Tester can be used by inspectors or utility crews.

#### Conclusion

All the methods presented in this chapter are valuable for checking the backfill of street repairs. These methods and procedures were presented here so cities and counties can have several alternatives for developing or updating their testing program. Since cities and counties generally have budget and manpower shortages, the Clegg Impact Tester is recommended. Being inexpensive and easy to use gives it an advantage over the other methods presented in this chapter.



**FIGURE 3.4**      **CLEGG IMPACT TESTER**

## CHAPTER IV

### TRAFFIC CONTROL FOR STREET CUTS

There are basically three important parts of traffic control: a) to get the work done; b) to keep the traffic moving with minimum disruption; and c) to maintain safety. Public agencies having authority over the roadway are primarily responsible for seeing that the above criteria are met. Establishing and maintaining current, up-to-date specifications help meet the above criteria. Utility Contractors must realize that any specifications used only serve as minimum standards for the most common situations. This is because it is not practical to develop detailed standards to meet all situations that may conceivably arise. Other than standard procedures can be confusing to the public. [11]

The public agency should have thorough inspection procedures to ensure that the utility contractors comply with established specifications. The Indiana State Highway Commission has developed a Manual on Uniform Traffic Control Devices. The manual has a complete section (section D)

devoted to Traffic Controls for Street and Highway Construction and Maintenance Operations. Most cities and counties have developed their specifications using this as a guide and require their specifications be used in conjunction with the manual. The same is recommended within this chapter.

Once the specifications have been established, utilities doing the work or having the work done share the responsibility with the public agency. At the job site, once the work begins, each worker is responsible for his/her safety, other workers' safety and safety to the motorist. The foreman at the job, the person in charge, takes direct responsibility for all workers' safety and the safety of the motorist. Safety is achieved by advance warning for motorists, visibility, protection of the work area and clear directions to traffic. [15]

Safety begins with basic protection. The workers must wear safety clothing or clothes which can be easily seen. One item of safety clothing usually worn is the orange safety vest. It is highly visible and does not restrict workers movement. Another item of safety clothing which OSHA (Occupational Safety and Health Administration) requires is the hardhat. Hardhats are important to workers' safety anytime they must enter excavations. Injury from a backhoe or other equipment is too great without the hardhat. Any person working on or near the road should have on safety clothing. Also, workers should face the traffic whenever

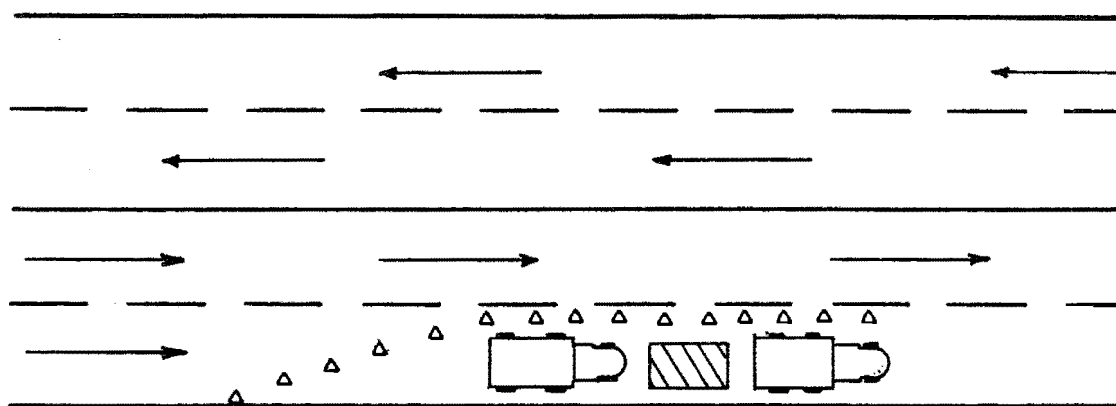
possible. A worker facing traffic has a chance to look up and see traffic coming. Also, equipment being used should be highly visible by drivers. The equipment and work area should be as far removed from traffic as possible. If this is not possible, the equipment should be placed between workers and the on-coming traffic. Figure 4.1 shows how the work vehicles or equipment should be placed.

#### Devices and How to Use Them

Every situation is different and must be analyzed that way. There are four variables which must be considered in the selection and implementation of traffic control devices. These will be used as guidelines for the discussion.

- Type of Work
  - (1) Location
  - (2) Time Involved
- Type of Roadway
  - (3) Speed
  - (4) Traffic Volume

Location and type of work involved are important questions. More traffic control devices will be needed when the work area is close to traffic. The work will generally be stationary in the case of street cut repairs. Stationary means the time will be relatively long term (longer than 15 minutes). If the repair is located on the roadway, maximum protection should be used to protect the workers and the motorist. The protection should start with warning the



# LEGEND:




TRAFFIC DIRECTION..	→
CONES .....	△ △ △
WORK AREA .....	
WORK VEHICLES .....	
ROAD .....	

FIGURE 4.1      EXAMPLE OF HOW TO PROTECT A WORK SITE WITH VEHICLES.

drivers well in advance of the work area. The warnings should give specific directions to the drivers, as the signs in Figure 4.2. Also, channelizing devices should be used to direct the motorist safely around the work area. Channelization varies with the speed of the traffic.

- (45 mph or greater) Taper Length = speed(mph) x lane width(ft.)

- (45 mph or less) Taper Length = lane width(ft.) x (speed) / 60 [15]

Below is a sample calculation for 55 MPH with an advance warning of 1500 feet on a four lane divided highway.

Given:	SPEED LIMIT	=	55 MPH
	LANE WIDTH	=	12 FT
	TAPER LENGTH	=	(55 MPH) x (12 FT)
	T.L.	=	660 FT

Cones or barricades should be placed about every 25 to 30 feet. Therefore 660 ft. taper/30 ft./cone = 22 cones. The set up should look like Figure 4.3.

The duration of the repair will determine the type of channelizing devices used. Cones should be used for repairs that last less than one day. For repairs that last overnight, barricades or barrels with steady burning lights should be used. Flashing lights are only to be used with obstructions. On heavily traveled roads, the repair work should not be allowed, if possible, between 7-9 a.m. and 4-6

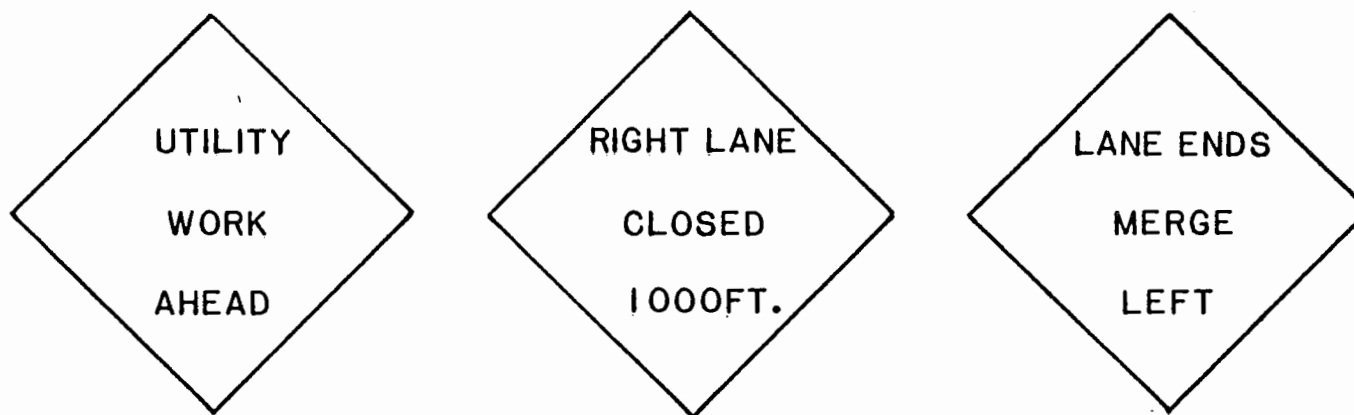


FIGURE 4.2 FOR THE DIMENSIONS OF THE WARNING AND ADVANCE WARNING SIGNS REFERENCE THE INDIANA MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (PAGES D23-D38). ALL SIGNS MUST BE REFLECTORIZED OR ILLUMINATED.



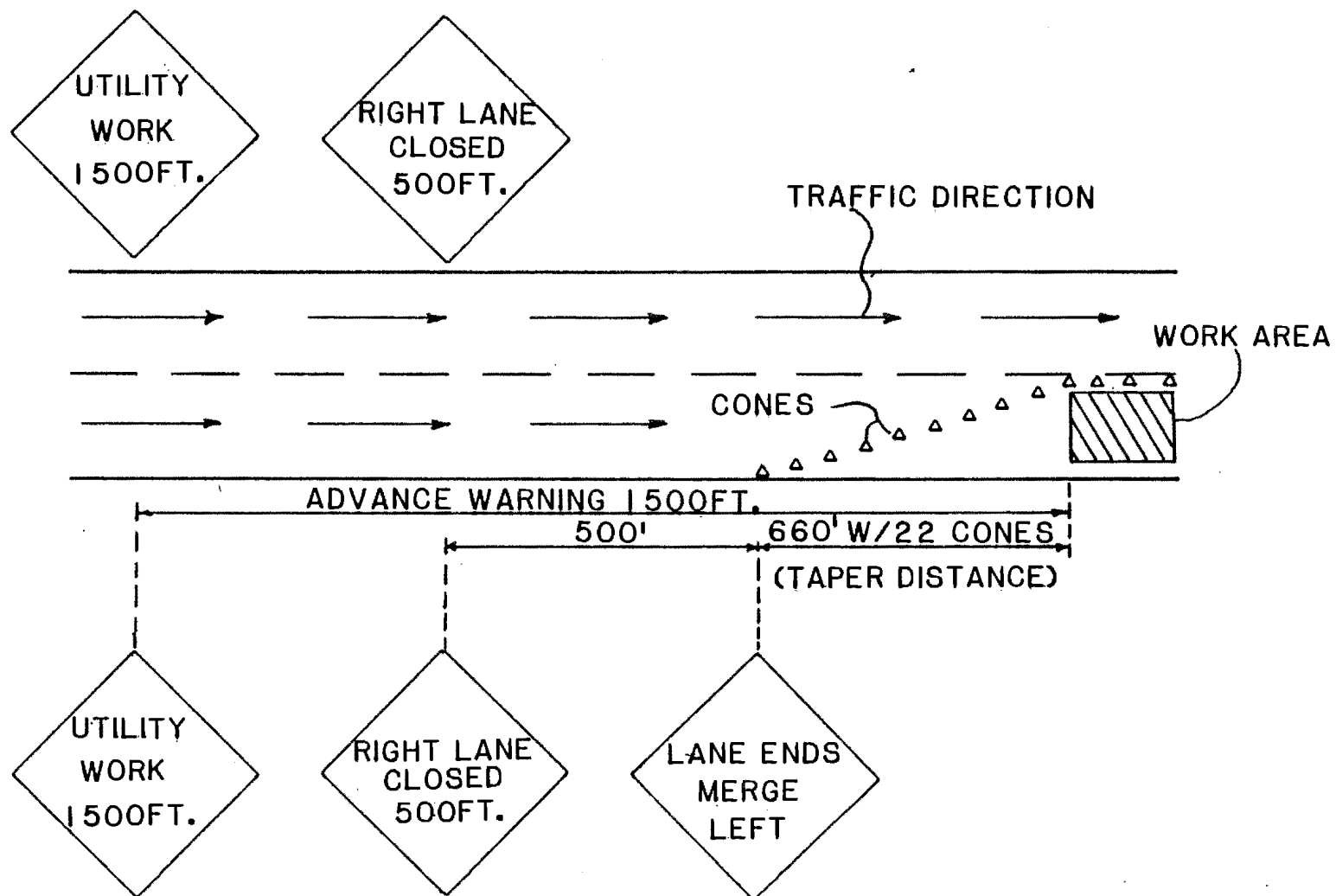


FIGURE 4.3 ADVANCE WARNING FOR UTILITY CONSTRUCTION ON A TWO-LANE ONE-WAY ROAD.

p.m. One possible way to avoid heavy volume times is to reschedule the work for night. The main traffic problem with night work is reduced visibility for the motorist. Therefore, increased warning and protection devices would be needed. For exact sizes of signs, cones and barricades refer to the Indiana Manual on Uniform Traffic Control Devices for Streets and Highways (Section D). This manual also gives details for sign placements.

As mentioned earlier the type of roadway establishes the speed and volume of traffic. Divided roads and undivided roads must be handled differently. For example, warnings must be given on both sides of the road for in lane repairs on a one-way road, reference Figure 4.3. For two-way traffic, both directions should be warned. For work along curves the taper must be placed so it ends at the tangent point of the curve, reference Figure 4.4.

The higher traffic volumes require greater visibility of devices. Elevated signs should be 7 ft. high. For lower volumes, rural roads, 5 ft. high signs are sufficient. Figure 4.5 gives the specific dimensions of these signs. Speed plays a major role in determining the devices used and their spacing. For high speeds, large signs should be used. For lower speeds, smaller signs can be used. Sign size dimensions are given in the above manual. Sign spacing is important. The spacing should be far enough from the repair for the motorist to react, but close enough to constantly remind

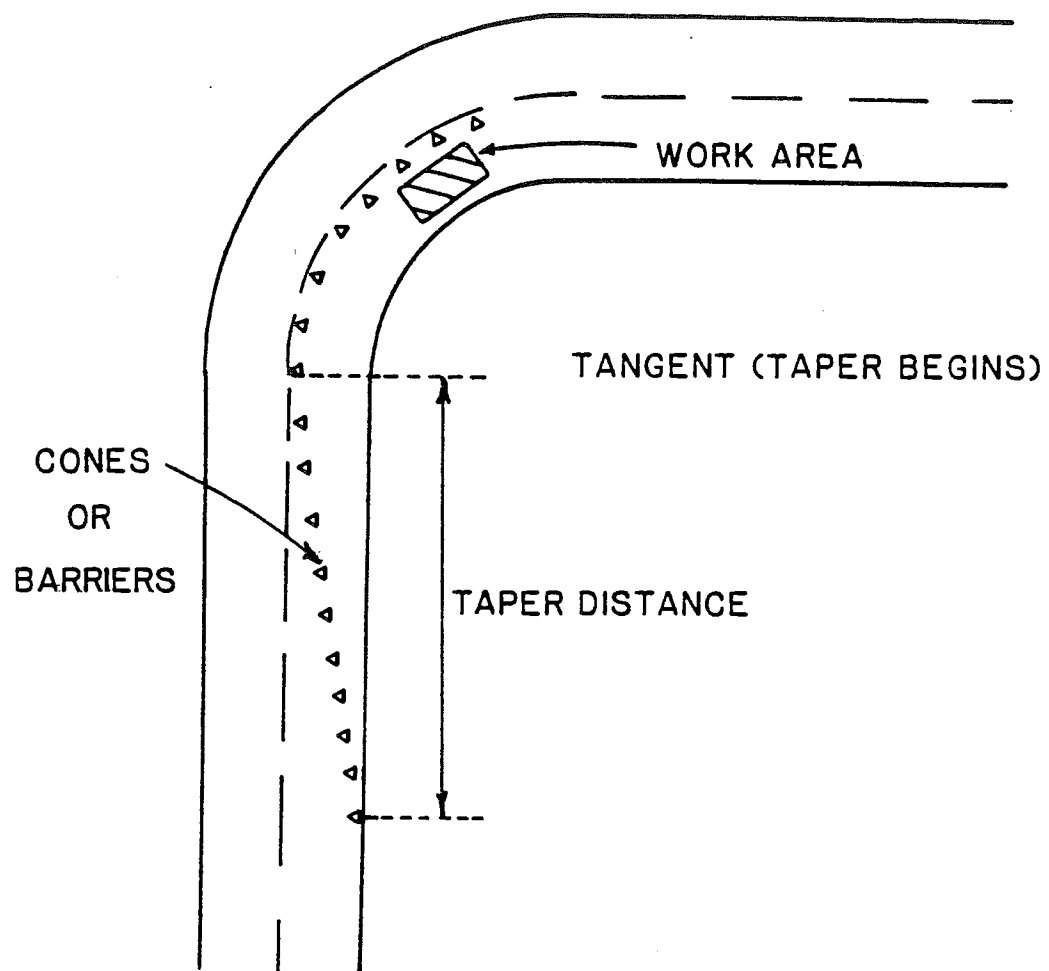


FIGURE 4.4 EXAMPLE OF A CONE TAPER GOING INTO A CURVE. (15)

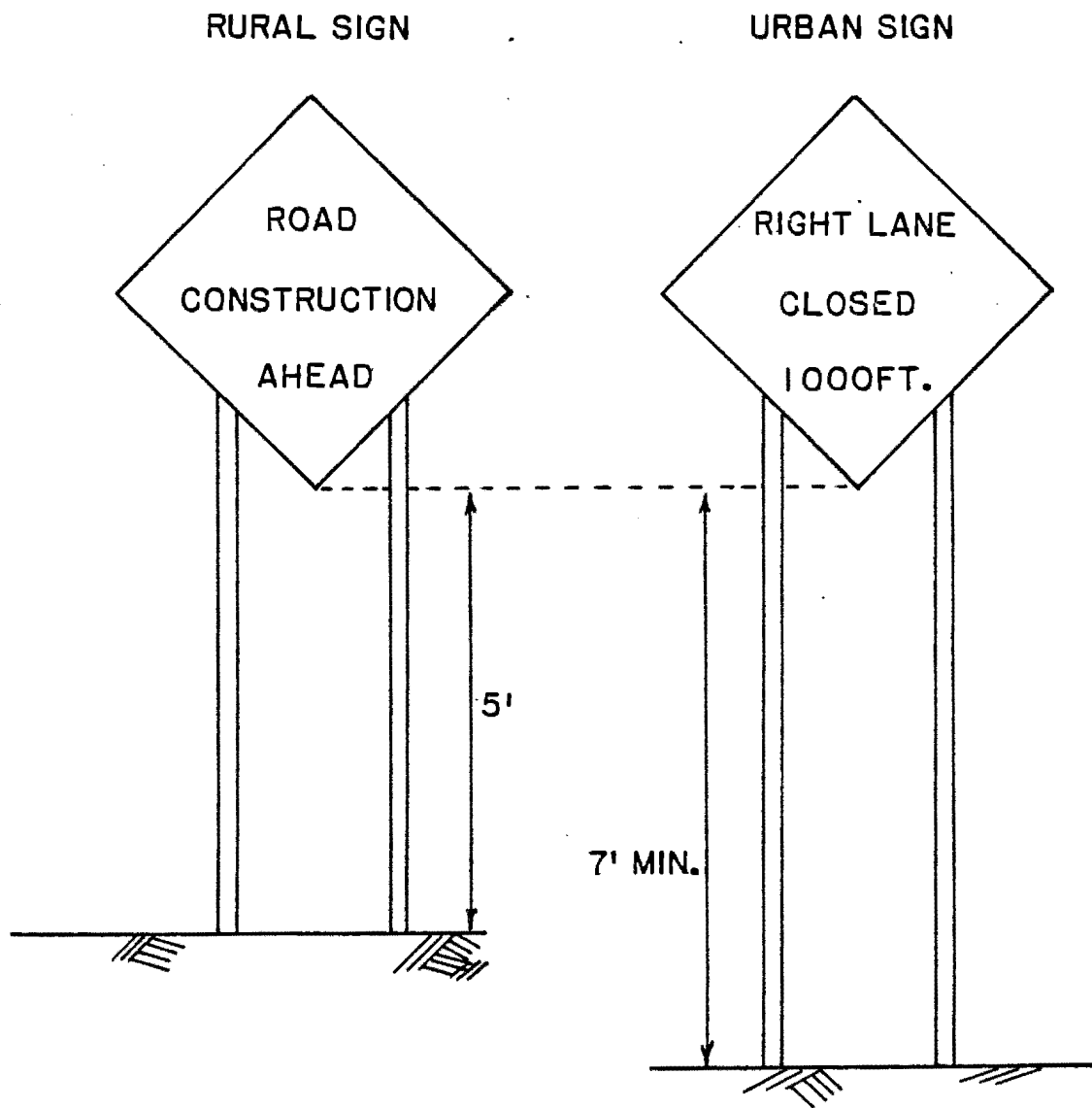


FIGURE 4.5 SIGN HEIGHTS (11)

the motorist, reference Figure 4.3. For high speed roads (over 45 mph), advance warning should be given at approximately 1500 feet in front of the work area. When a series of advance warnings are given, they should be placed at approximately 1500, 1000 and 500 feet in front of the work area (see Figure 4.3). The advance warning may not be necessary if a flashing light warning sign is visible from 500 feet in advance of the work site for speeds lower than 30 MPH. The flashing light warning sign should be visible from 1000 feet in advance of the work site if speeds exceed 30 MPH. For lower speed rural roads, the flashing light signs may be placed just in the immediate area of the work site. Work sites with warnings in the immediate area should still have a proper taper of cones or barricades. [4]

#### Procedures for the Use of Traffic Control Devices

The actual procedures for traffic control can be characterized by five phases:

- 1) Planning
- 2) Installation
- 3) Inspection
- 4) Maintaining
- 5) Removing

The Planning Phase consists of estimating the signs that will be needed, placement of work vehicles at the job site and calculation of taper for channelization devices. The public should be notified when traffic will be greatly

affected. This can be done by contacting the newspaper, radio and television. The public agency in charge on large projects should notify police, fire and ambulance services to be on alert. For the installation phase, traffic control devices should be placed in the order in which traffic will see them. After installation, the devices need to be inspected by a driver driving through the site as the average motorist would. This will help to determine if the signing and tapers are clear and easily understood. Once the devices are in place and inspected, they must be maintained for the duration of the utility repair. This is essential for the safety of the repairmen and the motorist. For longer term operations, sandbags can be used as additional weight for barriers and barrels to prevent them from being blown over. The signs being used should be removed when they no longer apply. The devices should be removed in the reverse order in which they were placed. [15]

Traffic control and safety at street cut repairs are essential to protect the workers and the motorist. This seems to be the area where most utilities or contractors hired by utilities are negligent. It is hard to say if the utility, the public agency or the workers are at fault. Therefore, it is important that the public agency take the initiative by establishing a well defined program of specifications and inspection, for traffic control and safety.

## CHAPTER V

### SOIL COMPACTION AND STABILIZATION

With the volume of cuts made, one would expect utility contractors to be experts with street cut repairs. This is not the case. In most cities and counties there are insufficient funds or too few personnel to furnish adequate inspections of street cut repairs. Therefore many utility contractors tend to dump the excavated material back in the hole without concern for moisture content or density of the fill. This procedure causes the road surface over the cut to settle from the compaction of traffic. This settlement could take place over several months or in a few days depending on the amount of traffic and the compaction by the repair crew. Cities and counties must do a better job of inspecting and making the utility contractors repair their work which has failed. If this procedure was implemented, it would be added incentive for the utility contractor to repair the cuts right the first time. It is much less expensive to repair the cut right the first time than to have to repair the same cut twice.

Compaction and stabilization are the keys to a quality

cut repair. This chapter attempts to present the important points of soil stabilization. City and utility company engineers can use this section to help produce quality street cut repairs for the cities.

#### Stabilization

The soil in a street cut may be unsuited, wholly or partially, to the standards of the construction engineer (or inspector). Thus, he must decide whether to:

- a. accept the soil and compact to specifications.
- b. remove the soil, and replace with a better soil which will then be compacted.

Soil properties may be altered in several methods, among which are chemical, thermal, and mechanical. Thermal is primarily used for large excavations and tunneling. Mechanical and chemical will be the primary methods discussed in this chapter. The variability of soil can often be as great over a few feet as over several miles. Therefore, the City or Utility Engineer working on the utility repair must understand the soil's variability. Due to the variability the choice of a stabilization method will often be determined by the soil's response spectrum. A soil's response spectrum is the number and type of soils in which a stabilization method has been found effective. Stabilization is not something which can improve every soil property for the better. Therefore, the engineer must understand the soil properties



that must be upgraded. This understanding of stabilization characteristics of various soils will be a key element in the decision of whether or not to stabilize the present soil or replace and stabilize. [14]

The basic properties of a soil with which the construction engineer is concerned are:

1. volume stability.
2. strength.
3. permeability.
4. durability.

#### Volume Stability

Many clay soils swell or shrink with changes in their moisture content. The expansive properties of a clay soil can cause severe problems for city engineers. The uncontrolled swelling due to seasonal moisture changes can disrupt road surfaces, break underground utility pipes and cause great economic losses. The swell and shrink of a clay soil is caused solely by the change in moisture content of the soil. By preventing the change in moisture content, the swell and shrinkage of a clay soil can be prevented. The seasonal change in the moisture content can extend to several feet in depth. Permanent change in the upper layers of a soil profile, due to a street cut, can change the mois-

ture content in deeper parts of the profile. If there is a change in the upper layers, no matter whether this causes a wetting-up or a drying-out of lower layers, some surface movement will follow. [14]

The moisture content is not a sufficient measure without the knowledge of permeability and soil clay type to determine the amount of surface movements. Surface movements can only be measured in the field. The magnitude is hard to duplicate or predict in the lab. This has been shown by clays exhibiting large swells in the lab, then in the field the clays show small net swell due to a lower permeability. Clays with a high permeability swell considerably more than clays with a low permeability. Mechanical densification reduces the clay soil's permeability thus reducing the amount of swell. The change in moisture content and permeability can be prevented by mechanical densification. Total prevention of these properties may not be economical, therefore densification should only be used to prevent seasonal changes in the moisture content and permeability.

Swell and shrinkage prevention of the replaced material has been the focus of the previous discussion. Prevention of these properties is not always the optimal solution, even if it is economical. What causes problems with road surfaces and underground pipe breaks is differential settlement. The replaced material needs to be compacted to

produce the same density (i.e. moisture content and permeability) as the existing. This is an impossible task, but experienced field engineers can usually make close matches. Specific densification procedures will be discussed in the next chapter.

### Strength

The strength (or deformation resistance) of a soil is a major problem with the fill in utility repair. There are several stabilization methods by which the strength or resistance to deformation of a soil may be increased. In organic soils these methods are only marginally effective. The use of mechanical stabilization is always considered to increase the strength of a soil. There are important exceptions to this rule such as when compaction causes excess pore pressures. This usually develops at an air void content below five percent. Excess pore pressures cause the material to lose all strength and the material will shove or rut under the compaction equipment. The effect of pore water pressure will be discussed later in the compaction section of this chapter.

The strength of a soil can be improved or controlled at existing conditions for utility cut fills by stabilization. The same mechanical compaction methods that improve volume stability are used for improving the strength of the soil. The moisture content and porosity of the soil have been identified as the major source of problems in the field.

Densification by mechanical compaction is the method most commonly used by utility companies and utility contractors to upgrade the mechanical properties of the soil. It should be emphasized that excessive densification can be a problem too. Densification should match existing material to prevent differential settlements.

### Permeability

The fill in most street cut repairs receive little compaction. This poor compaction leads to high permeability. The Webster's New World Dictory defines permeability as "the rate at which a fluid passes through a porous body." The hard lumps, due to hard clay or poor gradation, resist compactive effort and thus leave interstitial voids. For most soils the permeability can be altered. Figure 5:1 shows how permeability is reduced as the moisture content increases for a given compaction rate. To produce the maximum density (low permeability) of a dry permeable soil, the moisture content needs to be increased as compaction is applied. Then after the optimum moisture content is reached at maximum density, the permeability starts increasing again. The methods used for decreasing the permeability of a soil do not always improve the volume stability or the strength of a soil. In fact in some cases, reduced permeability by compaction will diminish these qualities. Thus, it is essential that utility contractors carefully consider the relative importance of all four major soil properties (volume

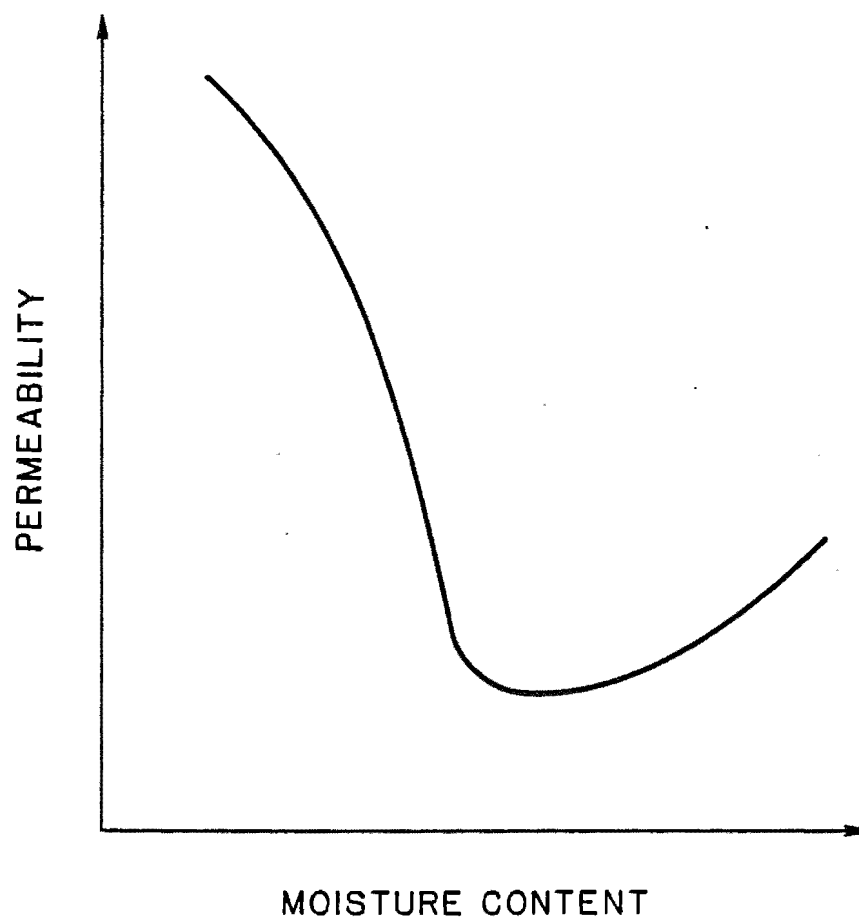


FIGURE 5.1 GRAPH PERMEABILITY V.S.  
MOISTURE CONTENT

NOTE: FOR A GIVEN COMPACTION RATE

stability, strength, permeability and durability) for the fill in each street cut repair before a decision is made on the type of stabilization to use. Problems in soil permeability can usually be handled by proper drainage, compaction and stabilization. [14]

### Compaction

Mechanical stability depends in large part upon the materials and equipment used. Density is also used in the determination of stability since most soil is strongest and most stable when it is well compacted. A soil is essentially a mixture of mineral particles, air and water. Mechanical compaction is the elimination of air from the above system. If a soil is placed in a container at some suitable moisture content and then compacted by impact or pressure and vibrated, it will become compact. Thus, there will be room for more soil in the container as the air is forced out of the soil. The relations between solid, water and air are defined by the parameters bulk density, dry density and moisture content.

Bulk Density = Total Weight/Total Volume

Moisture Content = Weight Water/Weight of Solids

Dry Density = Weight Solids/Total Volume

Most books consider the effects of compaction and stabilization in terms of "dry density" and "moisture content." By changing the moisture content of a soil, the soil's response to compactive effort (dry density) is changed. The

"moisture-density" curve is the most familiar method to represent this relationship. Figure 5.2 is an example of a soil compacted with the same compactive effort but at different moisture contents. [14]

Two features of the moisture vs. density graph, Figure 5.2, are of the utmost importance in construction involving earthen materials. The first is the "zero air voids" or "saturation" line which is theoretically calculated using the following equation:

$$P_d = \frac{SP_w}{\frac{SP_w}{P_s} + W}$$

where

S = saturation = 1.0

W = water content

P<sub>w</sub> = density of water

P<sub>s</sub> = density of solids

P<sub>d</sub> = dry density.

Saturation represents the condition in which all the air has been driven out. When saturation occurs the compactive force is applied to the water in the pores (as described earlier). The forces causes a pore water presssure which effectively prevents further compaction. It is not practical to force water out by compaction. Attempts to do so will cause pore water pressures to develop. The small

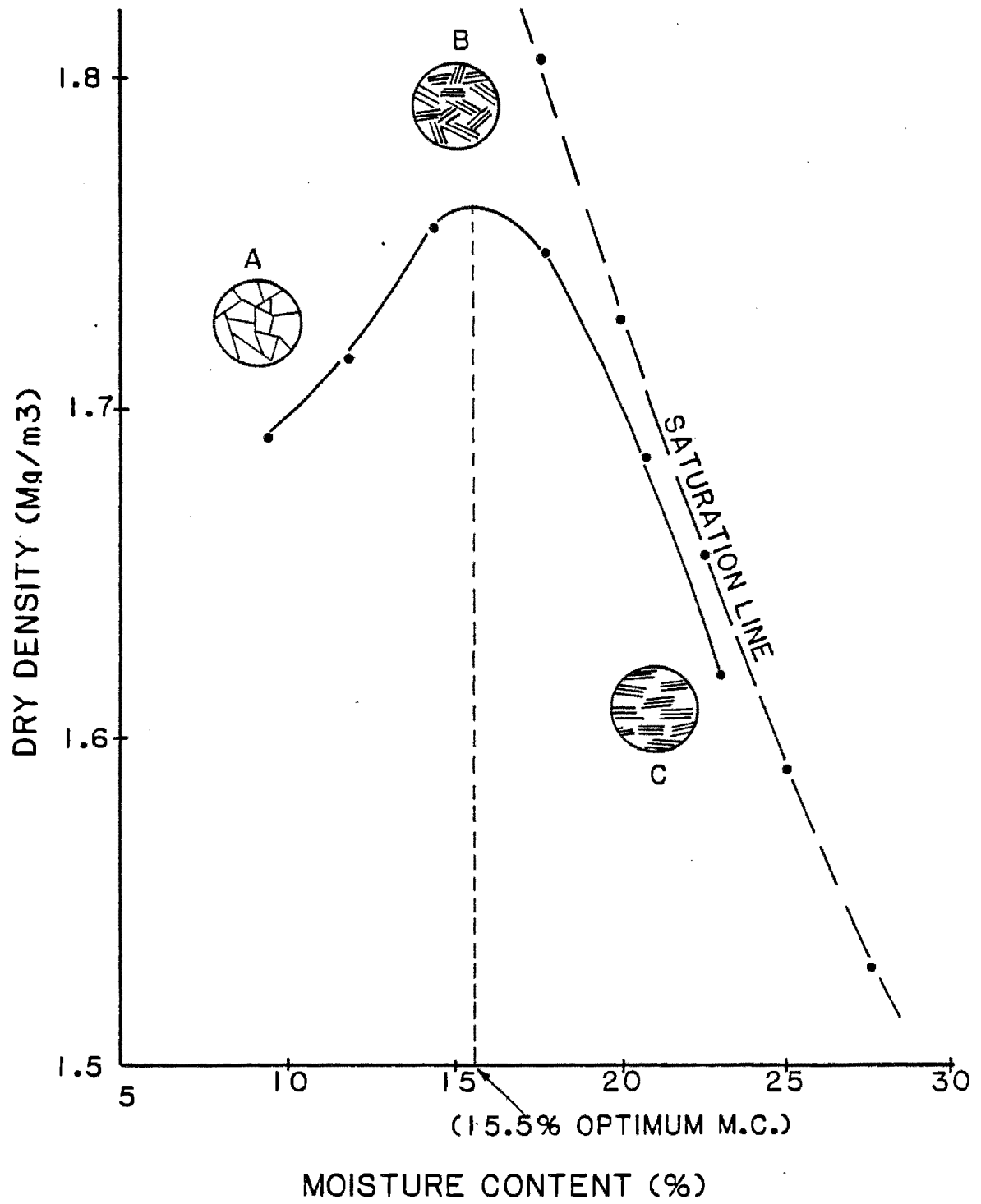


FIGURE 5.2 GRAPH DRY DENSITY V.S. MOISTURE CONTENT. (7)



diagram labeled C in Figure 5.2 shows the orientation of the soil particles when pore water starts to build. The particles are nearly parallel to each other and are more likely to slide over one another. Thus, this is an unstable condition. The second main feature of the "Moisture vs. Dry Density" curve is that a "maximum" density is related to a particular "optimum" moisture content, and compaction. The B diagram on Figure 5.2 shows the particle orientation at maximum density. The particles are very densely compacted at various angles to prevent sliding of the particles over each other. This is a stable condition. If compacted wet (higher MC) or dry (lower MC) of the optimum moisture content will give a lower dry density. A similar relation exists between density and moisture content for field compacted soil. When soils are compacted dry of optimum, the increasing strength within the soil particles and lumps resists degradation and deformation. Thus the compactive effort is no longer effective in increasing the density of the soil. The A diagram on Figure 5.2 shows the soil particle configuration when compacted dry of optimum moisture content. The particles are orientated in different angles like in diagram B. But the particles are not densely compacted. The soil is porous and thus susceptible to degradation by water. [14]

When aggregate is used for fill in street cuts, special care must be taken to the gradation of the aggregate. To

build a dense, strong, mass of aggregate, the interstices between the large aggregate must be filled with smaller stones. The space for air and water should be reduced to a minimum. Compaction and vibration is still required of well graded aggregate to compact them. Standard specifications have been set by the Indiana Department of Highways for the grading limits of aggregate. The grading limits coincide with the standard sizes used in sieve analysis. Tables 5.1 and 5.2 are the Indiana State Highway Department specifications. Figure 5.3 is an example plot of the coarse aggregate 53-B.

#### Conclusion

This chapter has presented the basic principles involved in soil compaction and stabilization. Utility contractors and inspectors need to have a firm understanding of this material to produce quality street cut repairs. With adequate compaction and stabilization, settlement can be reduced, if not eliminated. Since settlement is the major cause of utility cut repair failures, the cities and utilities should both save money if the engineers understand and apply these principles. Practical application of these theories will be presented in the next chapter.

Table 5.1. Gradings for Fine Aggregates (13)

Aggregates Sizes	Screen Sizes (Square Openings) and Total Per Cent Passing									
	3/8"	No. 4	No. 6	No. 8	No. 16	No. 30	No. 50	No. 80	No. 100	No. 200
14-1	100	95-100	---	80-95	---	20-50	5-20	---	0-5	0-3
14-2	100	98-100	---	75-95	50-75	20-53	6-25	---	1-17	0-3
17	---	100	---	90-100	55-85	20-55	5-35	---	1-15	0-5
15	---	---	100	90-100	---	50-75	15-40	---	0-10	0-3
16	---	---	---	---	---	100	---	95-100	---	65-100

TABLE 5.2      Gradings for Coarse Aggregates (13)

Total Percent Passing Sieves Having Square Openings														
	4"	3-1/2"	2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 8	No. 30	No. 100	No. 200
1	100	90-100	25-60	---	0-15	---	0-5	---	---	---	---	---	---	0-1
2	---	---	100	95-100	---	0-20	0-5	0-2	---	---	---	---	---	0-1
4	---	---	---	---	100	70-90	45-65	10-30	0-15	0-5	---	---	---	0-2
5	---	---	---	---	100	85-98	60-85	30-60	10-35	0-10	0-5	---	---	0-1
57	---	---	---	---	100	95-100	60-100	25-60	15-40	0-10	---	---	---	0-1
7	---	---	---	---	---	100	65-95	25-80	---	0-15	0-10	0-5	---	0-3
8	---	---	---	---	---	100	85-100	25-55	8-25	0-5	---	---	---	0-1
9	---	---	---	---	---	---	100	65-85	20-55	0-10	---	---	---	0-3
10	---	---	---	---	---	---	---	100	90-100	---	---	---	10-30	---
11	---	---	---	---	---	---	---	100	75-95	5-20	0-5	---	---	0-3
12	---	---	---	---	---	---	---	100	---	50-80	0-35	0-4	---	0-2
53	---	---	---	---	100	80-100	70-90	55-80	---	35-60	25-50	12-30	---	5-10
53B	---	---	---	---	100	80-100	70-90	55-80	---	35-60	25-50	12-30	---	0-5
73	---	---	---	---	---	100	90-100	60-90	---	35-60	---	12-30	---	5-10
73B	---	---	---	---	---	100	90-100	60-90	---	35-60	---	12-30	---	0-5

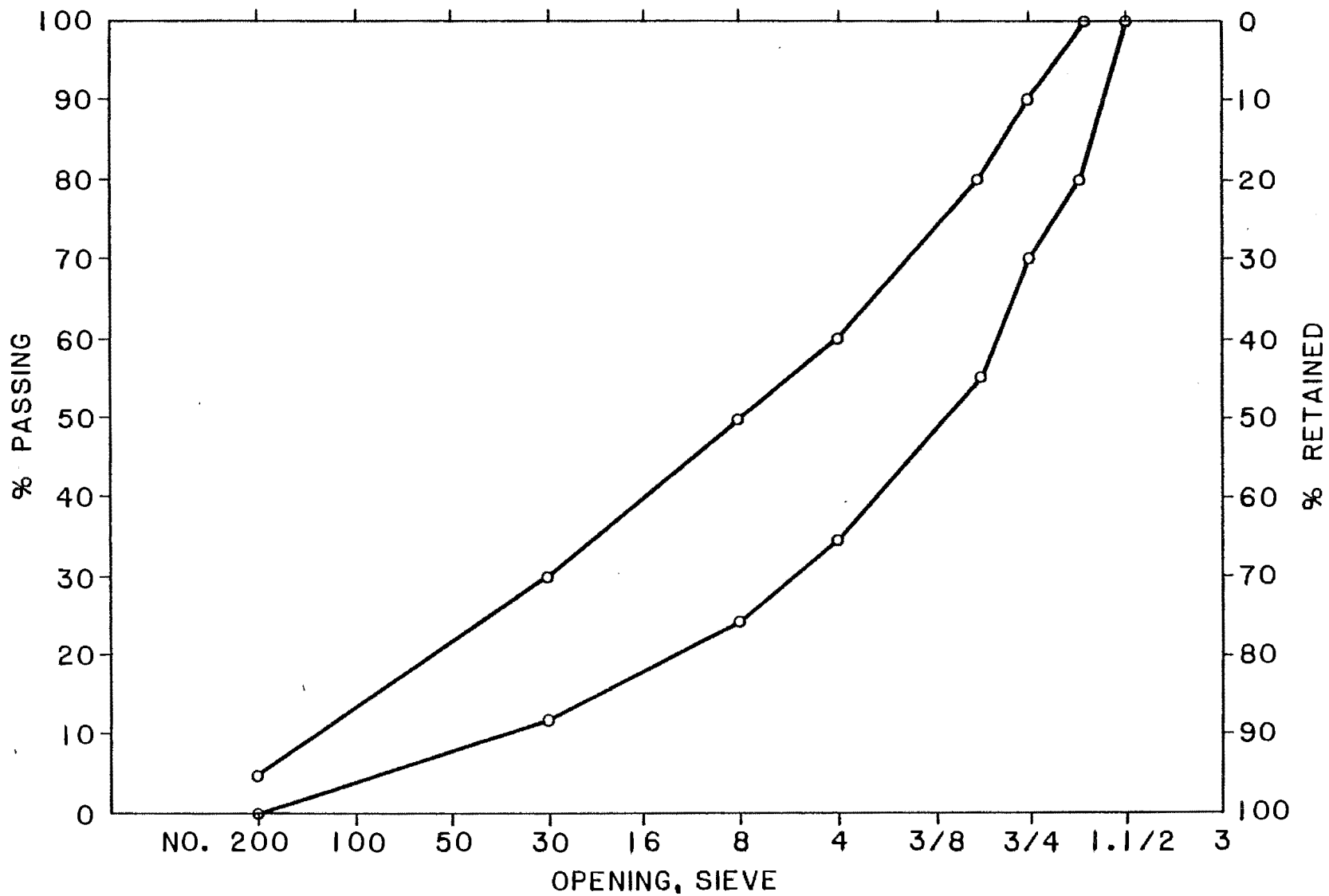


FIGURE 5.3 53-B COARSE AGGREGATE

## CHAPTER VI

### METHODS OF SOIL STABILIZATION

Chapter V presented the basic principles for compaction and stabilization. This chapter deals with the methods of obtaining the previously presented principles. In counties and cities, street repairs are usually backfilled with the excavated material. Granular material should be used if possible, except in clay soils. If granular material was used in a clay soil, the utility trench would become a drainage channel. Therefore, granular material is not always the best backfill. Granular backfills are more expensive than using the excavated material. The excavated material can be used for backfill if the boulders (larger than 3" diameter) are removed and it is compacted to its original density. Counties and cities must keep close control on utility contractors if excavated material is used for backfill.

Relative compaction is the measure used by most testers to check the compaction of a backfill. The equation is:

$$\text{Relative Compaction(R.C.)} = \frac{P_{d_{\text{field}}}}{P_{d_{\text{max}}}} \times 100(\%)$$

The recommended standard in Chapter VI is 95% RC. 95% is used because it would be practically impossible to obtain 100% compaction in the field. This is an end-product specification. End-product specification means, that as long as the utilities or contractors are able to obtain the specified relative compaction, how they obtain it does not matter. Therefore, this chapter presents several methods of obtaining relative compaction that have proven effective. Utility contractors should use the procedure which works best for them. [7]

#### Compaction and Stabilization Methods

Once it has been determined by the inspector or utility contractor at the repair site that the excavated material is unsuited for fill, several decisions must be made. Should the material be replaced or treated (with cement, lime or bituminous) to produce an adequate fill? A common fill material used to replace poor material in Indiana is the coarse aggregate 53-B (state classification). Used with the right compaction methods, this material can produce an inexpensive quality fill. Several other classifications of stone could be used to produce quality fills. Compaction of coarse aggregates will be discussed later.

An alternative to replacing the fill material, as mentioned before, is using cement, lime or bituminous materials to improve the soil characteristics. Lime is used with highly plastic, fine-grained soils. Contractors have been

using from 2 to 8% by weight of the soil with much success. When the lime is mixed and compacted, the swelling is reduced and workability of the soil is increased. Later the cementing properties of the lime gives the soil added strength. Lime can greatly improve the base characteristics of a soil. It generally costs about as much as cement. So for large areas this could be expensive, but for small street cut repairs it is economical. [7]

Cement provides an acceptable base with sands, silts and silty clays. In combination with poor base materials, it may be used for utility repairs. If a selected base material is used, cement can help improve its properties also. Cement greatly increases the soil's or aggregate's strength while reducing the material's permeability. The reduction in permeability helps increase its durability by reducing its exposure to freezing and thawing cycles.

Bitumen is used with granular soils, silts and silty clays. The bitumen strengthens and waterproofs the soil. With the granular soils, it makes a high quality base material. Several texts refer to the use of bitumen with soils as deep strength construction. [1]

The lime, cement and bitumen can be fairly expensive when used over large areas. The majority of street cut repairs are only about 25 ft in area. Using these materials should produce fewer street cut repair failures. Failures



mean the utility contractor must return to the site and redo the repair or patch the road. Therefore, the use of these materials could be economical for this size of street cut repair.

For granular backfill there are several means of compaction. Fine aggregates (sand) can be compacted or stabilized by mechanical compactors, saturation and chemical means. When mechanical compaction is used, the size of cut may determine which mechanical compactor is selected. For large open cuts, some type of vibratory plate compactor should be selected. For smaller excavations, a smaller compactor like the Bomag Soil Tamper T50 (118 lbs) or the Stomper VR-15 (135 lbs) should be used. Any type of compactor similar to these could be used. These are the ones used by the Indiana State Highway Department in their Pothole Repair Study. To get sand to the proper relative compaction, saturation is the most common method used. Saturation is quick and easy, but should not be used when the repair is surrounded by a soil with a high percentage of clay. Portland cement is the chemical means of stabilizing a fine aggregate backfill. This method was mentioned earlier.

[12]

Due to the expense of portland cement, mechanical and saturation are the most common means used to reach the specified relative compaction of fine aggregates.

For coarse aggregates, the most widely used method of compaction is mechanical compaction. Some moisture is added to lubricate the particles. The size of the cut, as with the fine aggregates, determines size of compactor to be used. For large areas a vibratory plate, Bomag T70 (175 lbs) or Wacker GVR 2201 (105 lbs) would be selected. For smaller areas the Bomag T50 (118 lbs), Stomper VR-15 (135 lbs) or similar machine should be used.

As discussed earlier, when soil is used for backfill, the material should be compacted in 6 inch loose lifts. Sprinkling the backfill before each compaction should help to achieve a higher density than if compacted dry. The compactors mentioned earlier should also be used on soils to achieve adequate compaction. Soils can also be stabilized by the chemical means mentioned earlier.

Another method which is similar to the chemical stabilization methods is a controlled density fill. Controlled density fill (CDF) can be made to densities of 90 to 135 pounds per cubic foot and compressive strengths can be produced from low to 1600 psi. Local site materials are selected for use in the mix. Controlled density fills will flow around structures and no special finishing is needed. The mix needs to be protected from loads for 4 hours. CDF can be easily excavated without caving in or running. The controlled density mix is available through local ready mix concrete suppliers under a licensing arrangement. The mix

is composed of cement, fly ash and other locally available materials. Controlled density fills are best used when a large quantity of backfill material is needed. It would not be practical to call a concrete mixer out for a small street cut repair. [3]

### Conclusion

The actual compaction and consolidation of the backfill and surface material is extremely important in order to produce a long lasting quality street cut. Cities and counties should consider setting up an inspection and testing program. This was discussed in the testing chapter, but is re-emphasized here.

## CHAPTER VII

## REPAIRS

When street cut repairs are made, the specifications determine the types of materials used during construction. The material specifications can make the difference between a quality street cut repair and a repair that fails. Below are the recommended minimum material specifications. They were taken from the Indiana State Highway Commission Standard Specifications 1978 and the Indianapolis Department of Transportation's Right-of-Way Manual 1981. All numbered or coded material below, refer to State specified material.

## Specifications

## I. Hot Asphaltic Emulsion

Base	No. 4, No. 5
Binder	No. 8, No. 9
Surface	Type III, No. 11, Type IV

## II. Hot Asphaltic Concrete

Base	No. 4, No. 5
Binder	No. 8, No. 9
Surface	Type B, No. 11, Type D

III. Cold Mix Bituminous      No. 53B Stone with 5.0-5.5%  
liquid asphalt

IV. Prime Coat                      Asphalt Emulsion AE-P

Cutback Asphalt MC-70

V. Tack Coat                        Asphalt Emulsion AE-T and

cutback Asphalt RC-70

VI. Granular Backfill

Subgrade                      Sand

Subbase                        No. 53 Stone

VII. Concrete

Cement Content    Six bag per cubic yard high early  
strength

Compressive Strength    3,500-4,000 psi

Slump                        2-4 inches unless certain  
admixtures are added

Air Entrainment    5 to 8 percent

Coarse Aggregate    Class A No. 5, 57 or 8

Fine Aggregate       14-1 or 14-2

Street cut repairs can take from several hours to several days. It is extremely important for the utility contractors to protect the open excavation from traffic and pedestrians. When crews are not in the area, the cut should be plated with a steel plate. A minimum thickness of three-fourths of an inch is required. The plates should be secured so they will not cause a hazard when traffic passes over them. Should the plates not be secured, the inspector needs to advise the utility or permit holder to take corrective action. If the permit holder does not take corrective

action immediately, the inspector should have the public works agency or another contractor place the steel plates. This needs to be done to protect the public. Then the permit holder should be fined for the cost of placing the steel plates and a reasonable penalty. [4]

Street cut repairs require the use of heavy construction equipment. Special care must be taken by construction crews to protect the existing pavement around the street cut repair. Any pavement surface that is marred or distorted during construction, by the utility contractor, shall become the permit holders' liability. The liability can mean the full removal and replacement by the permit holder at their own expense. Damage is generally caused by tracked excavators.

Another problem besides marred pavements is pavements with excessive street cut repairs. What the City of Indianapolis does after a road has been resurfaced is to record the total square footage of cuts in a block. The cuts could be made by one or more permit holders. When the total square footage exceeds 33% of the surface area in that block, the permit holders are liable for the resurfacing of that block. The liability does not exceed the cost of a one inch overlay of hot asphalt over the area to be resurfaced. For cities and counties to enforce a policy of this nature, the specifics must be established in their specifications. Undermining of existing pavements is another problem.

Specifications should state that any undermined pavement must be replaced during construction of the street cut repair. The reason for this is it is impossible to compact the material under the undermined surface. Once traffic loads are applied, immediate settlement generally takes place in flexible pavements. [4]

#### Long Term Repairs

There are many types of streets to deal with when making street cut repairs. The long term repair will be explained in three stages, which cities and counties must control. The three stages are 1) cutting the street, 2) backfilling and 3) surface restoration.

Cutting of Streets. The cutting depends largely on the type of surface to be cut. For asphalt, concrete and asphalt over concrete streets there are two basic methods used.

1. All cuts shall be sawed to 1/3 depth of the pavement and then completed with a mechanical hammer that has a cutting edge of at least 4 inches. A minimum saw cut of 2 inches is required.
2. All cuts shall be made with a mechanical hammer that has a cutting edge of at least 4 inches. Before final repairs are made, the cuts shall be "squared." The edges of all cuts are to be straight. [4]

For the chip seal and gravel streets the procedures vary. For chip seal pavements the cuts shall be made by a mechanical hammer with a cutting edge of at least 4 inches. Like above, the edges are to be straight and parallel. For gravel roads, cuts can be made by mechanical or manual means.

Backfilling. There are two methods that can be used for backfilling street cuts. A granular or controlled density backfill is recommended. The controlled density backfill will be discussed later. A granular backfill will be of sand or gravel. When sand is used, the backfill should be placed in less than 12-inch loose lifts. Each layer should be compacted by mechanical means or saturation to at least 95% of its maximum dry density. Care should be taken to check the surrounding subbase material. If the material is composed of mainly clay, then saturation is not recommended.

When gravel is used as the backfill, it should be placed in 6-inch loose lifts and compacted with moisture and mechanical tamping or vibrators. The Indiana State designated material 53-B seems to be the most widely used backfill material. Figure 5.3 shows the grading limits of the 53-B Coarse Aggregate.

As described in Chapter V, the excavated material can be used for backfill. If this method is used, the inspector



should make sure final backfill density is equal to or greater than before excavation. The check can be obtained by using the Clegg Impact Tester as described in Chapter III. The backfill should be compacted in loose lifts of 6 inches by mechanical compactors.

An alternative to conventional backfilling methods is the use of a controlled density fill. As explained earlier in Chapter VI, a controlled density fill can be made to densities of 90 to 135 pounds per cubic foot and compressive strengths from low to 1600 psi. There are several advantages to using controlled density fill (CDF).

1. CDF needs no tamping labor.
2. CDF can be made to any consistency.
3. CDF flow readily in and around pipes.
4. CDF can easily be made to meet density and/or strength specifications.
5. CDF can be applied without forms or support.
6. CDF can be worked on within hours under normal conditions.
7. CDF can be cut or trenched without caving in or running. [3]

As can be seen the controlled density fill could save utility contractors a lot of money in labor costs and also provide a well compacted subbase material.

Surface Restoration. Surface restoration depends on the existing surface. All pavement should be replaced with similar paving materials. For asphalt pavements, all edges or joints of the existing pavement shall be cleaned and tack coated prior to the placement of the new asphalt. The new asphalt shall be placed in three inch compacted lifts. The lifts shall be compacted by a mechanical tamp or vibrator. The Indiana State Highway Department used the Bomag T50 "Stomper" and the T70 "Wacker" as compactors in their Pothole Repair Study. They found these machines were very effective in compacting and reducing the time needed for adequate compaction. Small pole type compactors should not be used for utility cut repairs. The pole type compactor refers to the Racine pole compactor used in the Indiana Department of Highways Pothole Repair Study. Pole compactors usually have a compacting foot of about 6 inches in diameter. The main reason they should not be used is, it takes too long with pole type compactors to reach adequate compaction. Figure 7.1 shows a cross section of an asphalt repaired utility cut. [12]

For concrete streets, the reinforcement should be similar to the existing material. The new reinforcing bars should be drilled and grouted into the existing pavement.

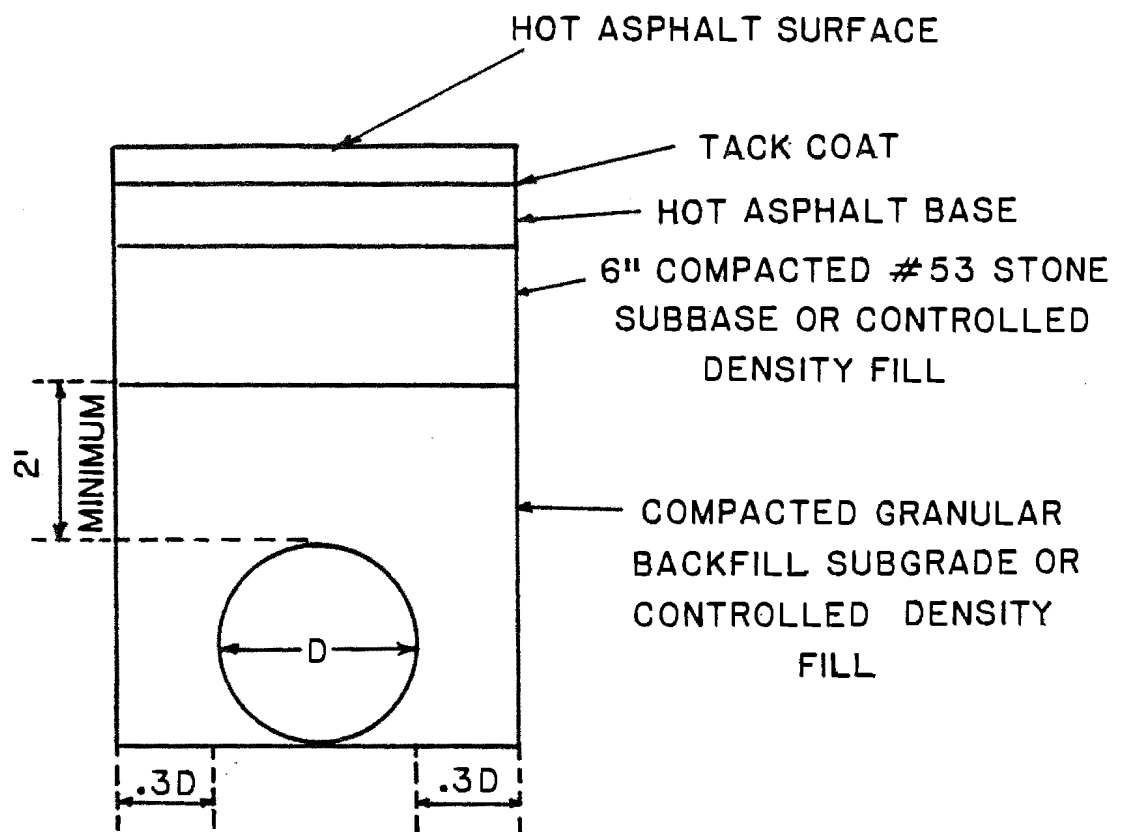


FIGURE 7.1 UTILITY REPAIR CROSS SECTION OF A ASPHALT ROAD. THE DEPTHS OF THE ASPHALT COURSES VARY AND SHOULD MATCH THE EXISTING PAVEMENT.

(4)

The new concrete shall have 6 bags of cement per cubic yard, high early strength (4000 psi). The freshly placed concrete must be protected against excessive dehydration. The protection can be of several types. A membrane type curing compound or wet coverings, such as burlap are the most popular. The repaired cut should be protected from traffic for at least 36 hours. The repair can be opened to traffic if steel plates, mentioned earlier, are used. Figure 7.2 shows the cross section of a concrete repaired utility cut. [4]

For streets that are asphalt over concrete, the above procedures still apply. The only difference is that a tack coat is needed between the concrete and asphalt. Figure 7.3 shows an asphalt over concrete repaired utility cut. It must be stressed that streets must be repaired with paving materials similar to existing materials. With the increase in popularity of recycling asphalt, more and more milling machines are being used. The milling machines mill off the old asphalt surface so new or recycled mixes can be placed. Concrete patches in asphalt streets dull or break the teeth from the milling machines. This is the main reason for replacing repairs with existing patch materials.

For gravel streets, the compaction needs to be the same as coarse aggregates for backfill. Figure 7.4 gives a cross section of how the street cut repair should look.

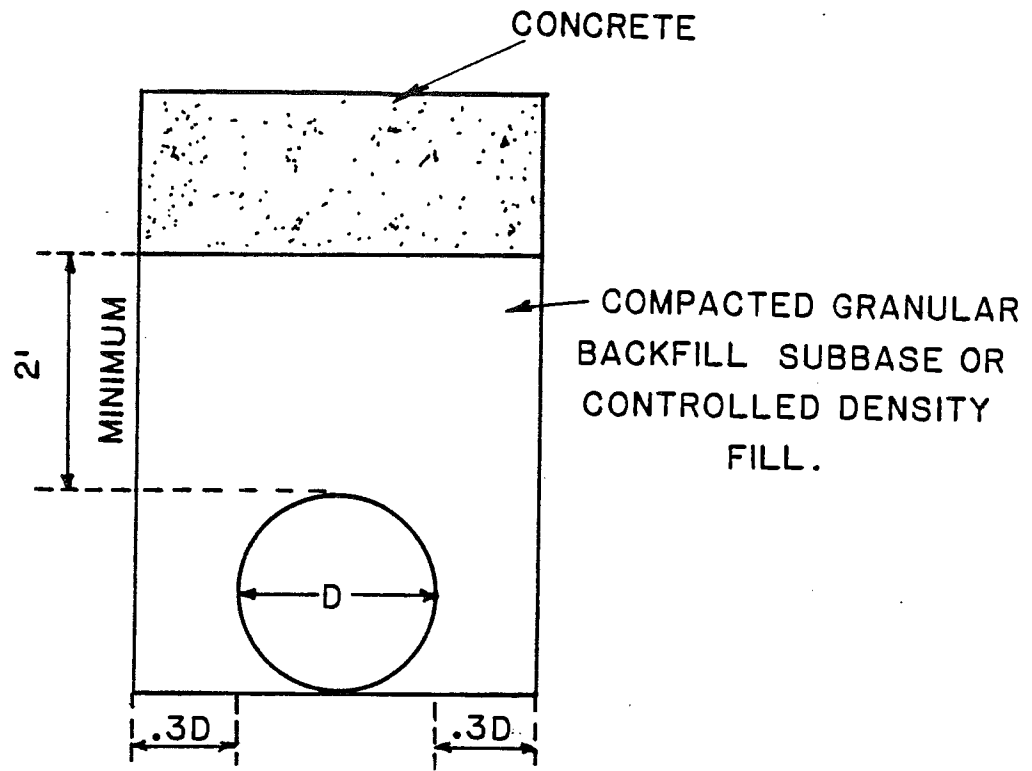


FIGURE 7.2 UTILITY REPAIR CROSS SECTION OF A CONCRETE ROAD. THE DEPTH OF THE CONCRETE SHOULD MATCH THE EXISTING PAVEMENT. (4)

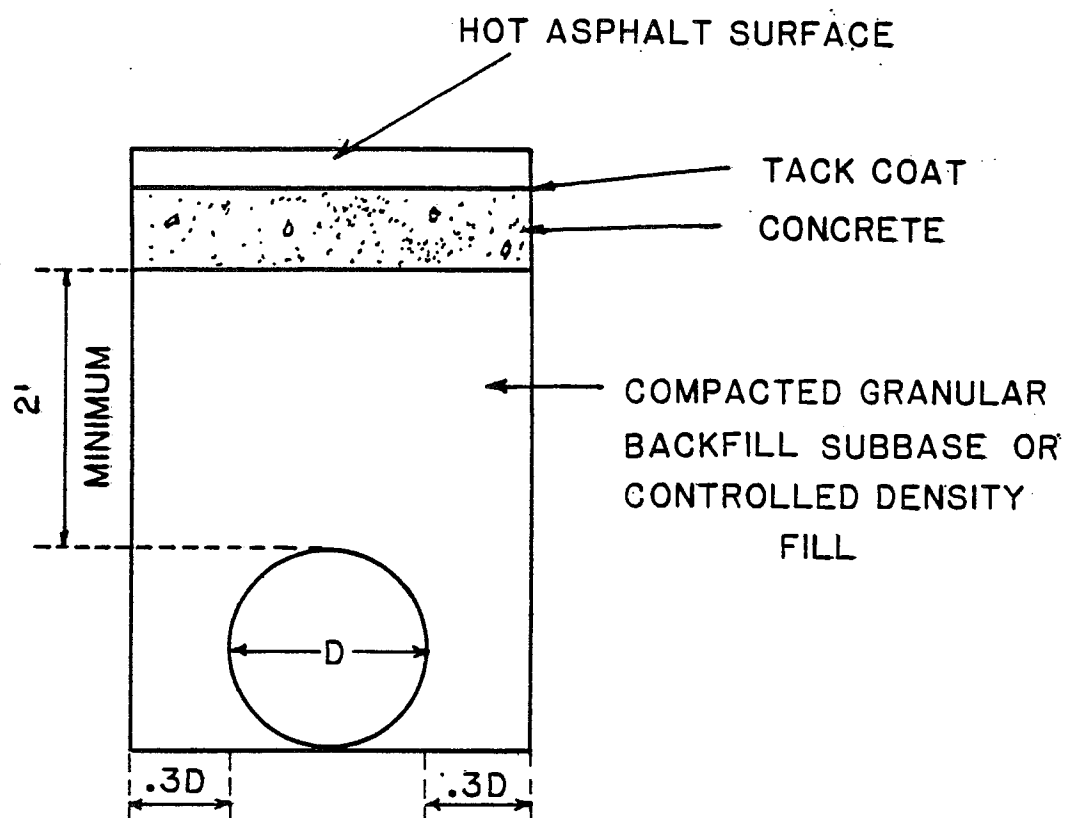


FIGURE 7.3 UTILITY REPAIR CROSS SECTION OF AN ASPHALT OVER CONCRETE ROAD. THE DEPTHS OF ASPHALT AND CONCRETE SHOULD MATCH THE EXISTING PAVEMENT.  
(4)

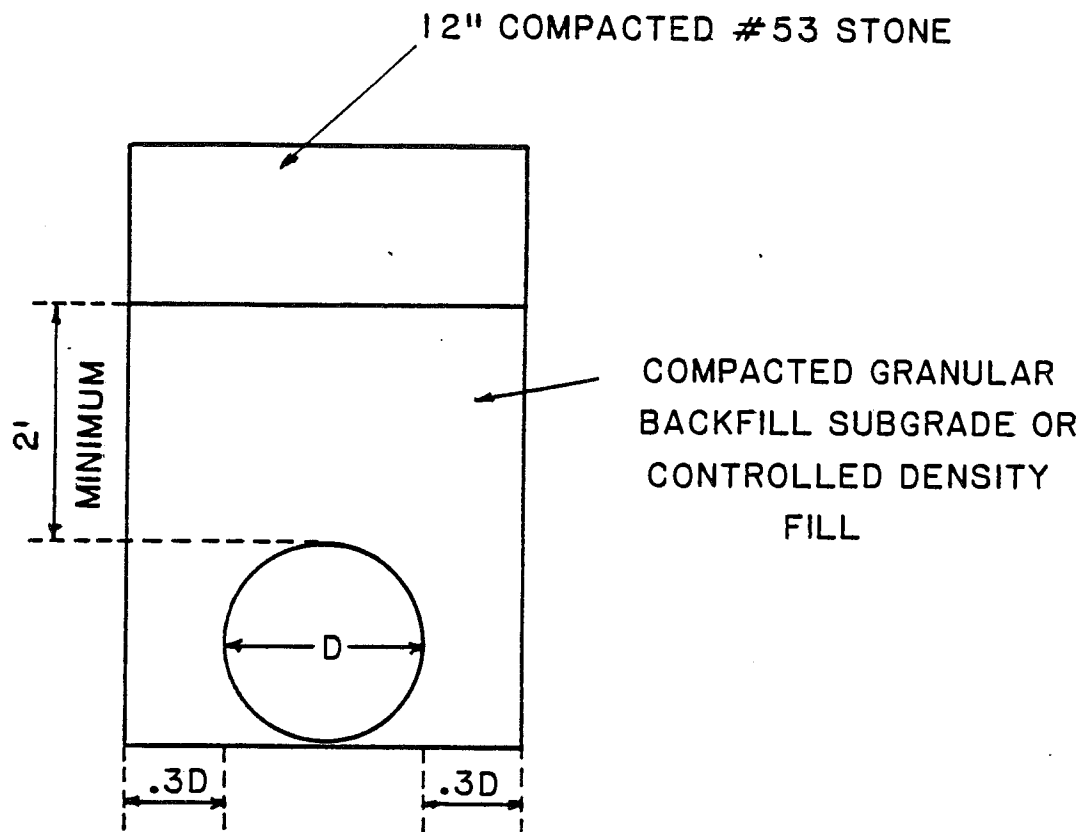


FIGURE 7.4 UTILITY REPAIR CROSS SECTION OF A GRAVEL ROAD. (4)

## Temporary Repairs

During the winter months, long term repairs may not be possible. Therefore, temporary repairs must be made until the weather is suitable to make a long term repair. The street cutting procedures are the same as long term repairs. The only difference is with backfilling and surface treatment. The backfill should be a coarse aggregate like the #53 stone. The stone should be compacted as well as possible. Then a cold bituminous mixture can be placed. In several cities within the state, utilities have had problems with cold bituminous mixtures. This can be seen from the Indiana Department of Highways Pothole Repair Study. Table 7.1 shows how many potholes failed when repaired with cold bituminous mixes. Therefore, several utility contractors use concrete as a temporary surface material. Concrete is even used temporarily on asphalt streets. Then in early spring, before June 15, the temporary patches should be torn out and repaired as stated in the Long Term Repair section. For a cross section of a temporary repair reference see Figure 7.5. [12,17]

The above methods of repairs were achieved by reviewing several cities and state specifications. These are presented as a guide for cities and counties to up-date or develop their own specifications. It must be stressed that clear communication to the utility contractors of their obligations, when they make road cuts is essential. No fines should be issued until the utilities are informed what



Table 7.1. Pothole Failures (Original Study) (12)  
(Placed Between March 14 and April 30, 1979)

Number Patches Placed	Total Placed = 288 Potholes	Type of Failure			Total Failures	Percent Failures
		Settlement (1)	Shoving (2)	Settlement & Shoving		
36	Heated, maximum hole preparation, mechanical compaction Tack and sealed, sanded (weather: cloudy, dry, 31°F)	4	5	5	14	38.9
36	Heated, maximum hole preparation, manual compaction tack and sealed, sanded (weather: sunny, dry, 37°F)	2	4	0	6	16.7
36	Heated, minimum hole preparation, mechanical compaction no tack used, sealed, sanded (weather: cloudy, dry, 44°F)	0	6	0	6	16.7
36	Heated, minimum hole preparation, manual compaction no tack used, sealed, sanded (weather: sunny, dry, 55°F)	0	3	0	3	8.3
36	Cold, maximum hole preparation, mechanical compaction tack and sealed, sanded (weather: cloudy, dry, 25°F)	17	1	2	20	55.6
36	Cold, maximum hole preparation, manual compaction tack and sealed, sanded (weather: cloudy, damp, 32°F)	34	0	0	34	94.4

Table 7.1. Continued (12)

Number Patches Placed		Type of Failure			Total Failures	Percent Failures
		Settlement (1)	Shoving (2)	Settlement & Shoving		
36	Cold, minimum hole preparation, mechanical compaction no tack used, sealed, sanded (weather: cloudy, damp, 55°F)	30	0	0	30	83.3
36	Cold, minimum hole preparation, manual compaction no tack used, sealed, sanded (weather: cloudy, damp, 40°F)	18	2	0	20	55.6

Failures in Heated WS Mix = 29 each or 20.1% Failures

INDIANA STATE HIGHWAY COMMISSION  
RESEARCH AND TRAINING CENTER

Failures in Unheated WS Mix = 104 each or 72.2% Failures

(1) Settlement failure was one where the mix settled 3/4 or more inches.

(2) Shoving failure was one where the mix is being pushed out of the pothole.

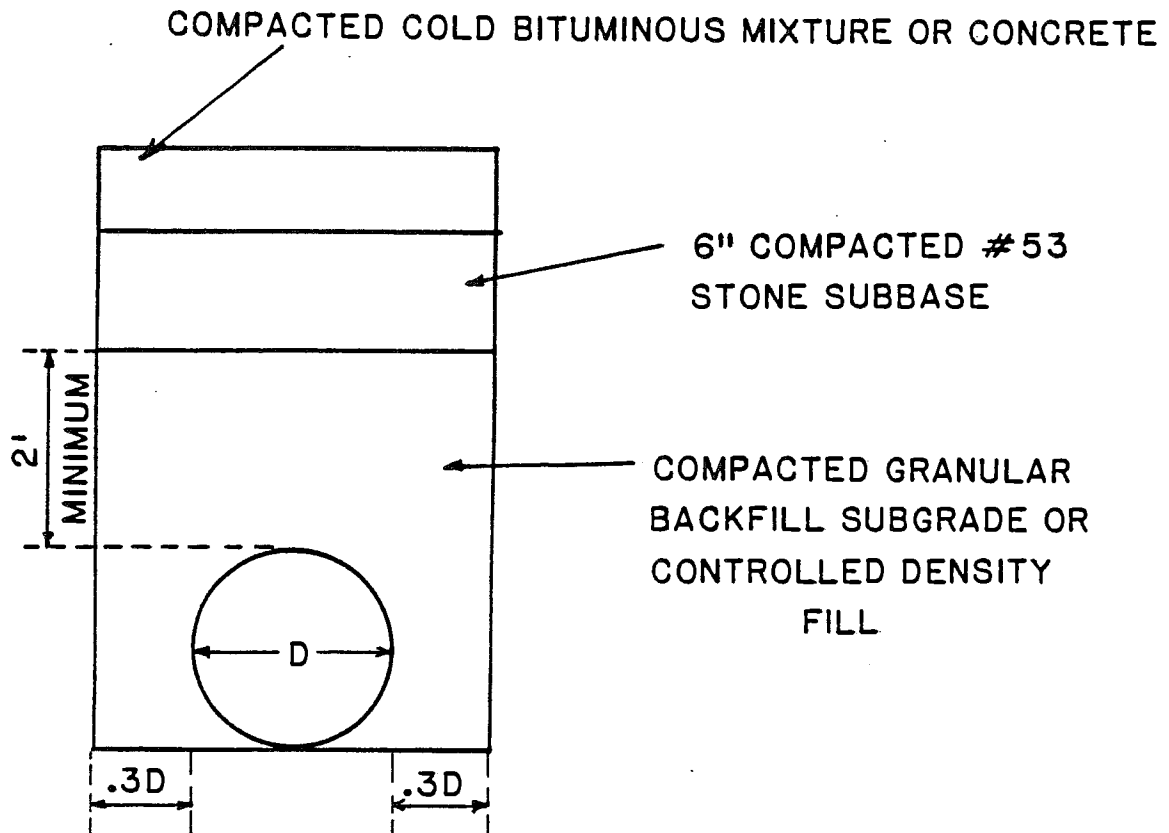


FIGURE 7.5 TEMPORARY UTILITY REPAIR CROSS SECTION OF ASPHALT, CONCRETE OR ASPHALT OVER CONCRETE ROAD. THE DEPTH OF THE SURFACE COURSE MAY VARY DEPENDING ON EXISTING PAVEMENT DEPTHS. (4)

is required of them. A good policy which the Indianapolis Department of Transportation has instated is: before a permit is issued, the utility or contractor, buying the permit, must purchase or show proof of ownership of a Right-of-Way Activity Manual. The Right-of-Way Activity Manual contains all the specifications and states all the liabilities of utilities or contractors working in the right-of-way.

## CHAPTER VIII

### ALTERNATIVES TO UTILITY CUTS

Utility pipes, beneath pavements, are subjected to various loads which cause them to crack, break and leak. Dynamic loads are constantly being applied to them through the base material by traffic. Sometimes breaks are produced by differential settlements which are caused by a wetting up or a drying out of the sub soil. Immediately after a road is resurfaced is when people notice the street cuts. In some situations, this is the time when leaks are started. The old pipes are subjected to the heavy vibratory loads used to compact the bituminous surface. Most cities and counties refuse to issue street cut permits for a period of 2-5 years after the road is resurfaced, unless an emergency arises. There are many other reasons for requiring alternative methods to street cuts. Heavy traffic is one of these reasons.

Utility contractors have had to find other means to replace damaged pipes since street cuts were not allowed on resurfaced streets. Presently there are three methods of untrenched construction used in Indiana. Old leaky pipes

can be replaced by jacking, coring or boring. All three are being used and provide utility contractors with valuable alternatives to street cuts. Generally utilities call in specialty contractors to handle untrenched construction. For county and city streets the pits for the untrenched construction should be located a minimum of 10 feet from the edge of the street. Pits should be excavated no more than 48 hours in advance of untrenched construction and backfilled within 48 hours after construction is completed. While the pits are open, they should be marked and protected by barricades. Shoring shall be required for any excavation over 5 feet. The shoring shall be designed, erected, supported, braced, and maintained so that it will safely support all vertical and lateral loads during construction. [9]

Jacking is one of the most popular untrenched methods in the state for pipes less than 6 inches in diameter. A casing or corrosion resistant carrier must be used. Driving works most effectively in compressible soils. A steady thrust, hammering or vibrating is needed to drive the pipe with a pilot shoe. The city of Alexandria used a backhoe to provide the steady thrust. Driving should not be used for long distances. Long drives may wander far from the desired line and grade. [9,16]

Boring is another popular alternative to street cuts. Large pipes can be jacked through oversize bores, carved progressively ahead of the pipe. The auger should not

exceed the outside diameter of the following pipe by more than 1 inch. The spoil is mucked back through the pipe. Line and grade are easy to control. A grout backfill shall be used for pipes more than 12 inches in diameter and for overbreaks, unused holes, or abandoned pipes. [16]

Coring is the third alternative to utility cuts. This method is mainly used when driving becomes too difficult in hard soils. Line and grade are fairly easy to control with coring. A small casing (6" or less) without a pilot shoe is drilled into the difficult soil. The soil enters the pipe as it advances. Then the core is removed by sluicing, during or after the drilling. [9,17]

More cities and counties are turning to these methods to prevent traffic disruption and eliminate street cut settlements. City and county engineers should stay in touch with local contractors and utilities on their abilities to do untrenched construction. As stated earlier, untrenched construction is a specialty item that demands special skills.

## CHAPTER IX

### SUMMARY OF RESULTS AND CONCLUSIONS

In this project, various procedures and methods were presented on the proper way to make street cuts. The engineer from each county and city should evaluate his current street cut program. Then he should update or round out his current program with, not necessarily the recommended procedures, but the procedures that best fit the county or city's individual needs. This chapter presents a summary of the recommended methods for county and city engineers.

The performance bond is important to insure that the county or city gets a quality job. A minimum of \$2500 (1981 figure) should be set for each street cut. The performance bond should be held for a period of one to two years after the street cut is made. Some cities and counties have set up an agreement with utility companies stating that they are responsible for the cut until the road is resurfaced. In turn the utilities do not have to maintain a performance bond. This works well for the city of Indianapolis. This agreement should not be made with individual contractors or



plumbers.

Permits are an important part of a street cut program. The permit should tell where the cut is located and who is responsible for the work to be done. Also, the permit costs help to pay processing and inspection costs. Currently the recommended method for cities and counties is a flat 5-10 dollar handling fee and a flat rate (per visit) for inspection services. A 10-15 dollar (1983) charge per visit for inspection services is reasonable. The follow up inspection, 6-12 months later, should not be charged to the permit holder.

Specifications protect the cities and counties from low quality work. The specifications must be clear and all parties making street cuts must be required to follow them. This goes for county and city forces too. The recommended material specifications are presented in Chapter VII. Due to their length, they will not be presented in this section. It is stressed that the specification "replace with as good or better than original condition" is not a substitute for an up-to-date set of specifications.

A good set of specifications needs to be followed with an active inspection program. The inspection does not have to be made by an engineer. The inspection, along with occasional testing will show the utility contractor that he is being checked. Utility contractors will start following

specifications if they are fined a few times or required to replace a bad repair with specified materials. With a good inspection program, it will be more economical for the utility contractors to make a quality street cut repair the first time instead of having to rework the same repair twice. Also, utilities should be required to mark their street cut repairs with the paints listed in Chapter 2. The paint will help the inspector, 6-12 months later, determine who made the cut if there is a failure.

Penalties need to be set for firms working without permits or not doing work up to specifications. The city or county engineer must determine reasonable fines. Several cities use a \$50 fine (1983 figure) for working without a permit. [4] This is a good figure for a first time offender. The penalty should be doubled or tripled for second and third time offenders. Individual contractors or plumbers should not be issued any more permits until all fines have been paid. This policy would not work with utility companies, so after two weeks or a designated period, the fine should be increased.

Besides the above recommended methods and procedures, several other characteristics were common to cities and counties with a good street cut program. One of the most common procedures was the follow up inspection. For all street cuts, the follow up inspection should be done 6-12 months after the repair. For individual contractors an

additional inspection should be done 1 to 2 years later before the performance bond is released. Good communication between county, city and utility engineers was another common characteristic. Many cities and counties had monthly meetings with all the utilities present to discuss problems or future plans of the city, county or utilities. For example, letting the counties know way ahead of time about any road construction is important. The utilities need to be able to get their repairs done before road crews start. Good communication cannot be stressed enough.

Quality street cut repairs are possible. In fact, many are being made. But the bad repairs are the ones people notice. City and county engineers can, without too much effort, greatly increase the quality of the street repairs in their county or city. After all, the motoring and bicycling public deserves a smooth riding surface or the best that their tax dollars can provide.

## BIBLIOGRAPHY

## BIBLIOGRAPHY

1. Atkins, Harold N., Highway Materials, Soils, and Concretes, Reston, Virginia: Reston Publishing Company, Inc., 1980, pp. 1,93,94, 96,165.
2. Baldwin, Bob, personal interview, Indianapolis Department of Transportation, Indianapolis, Indiana, May 1983.
3. Brewer, William E., personal interview, Brewer and Associates, Toledo, Ohio, June 1983.
4. City of Indianapolis Department of Transportation Right-of-Way Activity Manual, February 1981, pp. 1,7,13,51,123,142,149,150,156, 158,159,161,179.
5. French, Robert, personal interview, Alt and Witzig Engineering, Indianapolis, Indiana, May 1983.
6. Garrick, Norman W., Field Evaluation of an Impact Testing Device for Measuring Base Course Strength, Purdue University: Masters Thesis, 1983, p. 4.
7. Holtz, Robert D., Kovacs, William D., An Introduction to Geotechnical Engineering, Englewood Cliffs, NJ: Prentice-Hall, Inc., 1981, pp. 143,152,161,165.
8. Indiana Department of Highways, "Policy Letter HO-MN-174", November 3, 1981.
9. Indiana Department of Highways, "Utility Policy Letter", January 1981.
10. Indiana State Highway Commission, Manual for the Use of Nuclear Gauges to Determine Field Density and Moisture of Construction Materials, January 1977, p. 5.
11. Indiana State Highway Commission, Manual on Uniform Traffic Control Devices for Streets and Highways, 1975, pp. 1, D-7.

12. Indiana State Highway Commission, Pothole Repair Study, Final Report, 1979, p. 12,17.
13. Indiana State Highway Commission, Standard Specifications, 1978, p. 468,472.
14. Ingles, O. G., Metcalf, J. B., Soil Stabilization Principles and Practice, New York: John Wiley and Sons, Inc., 1972, pp. 1,4,14,56.
15. Institute of Transportation Engineers, "Selection and Use of Devices", slide tape presentation 1982, slides 9, 74, 82, 85.
16. Tennessee Department of Transportation Bureau of Highways, Policy and Procedures for Accommodating Utilities within Highway Rights-of-Way, February 10, 1970, p. 12.
17. Webster's New World Dictionary, 2nd ed., Cleveland, Ohio and New York: William Collins and World Publishing Co., Inc., 1975, p. 556.

## APPENDICES

## APPENDIX A



# APPENDIX 1A

## TENNESSEE DEPARTMENT OF TRANSPORTATION SURETY FORM

### S U R E T Y   B O N D (For Utility Permits)

KNOW ALL MEN BY THESE PRESENTS:

That we \_\_\_\_\_, PRINCIPAL,  
and \_\_\_\_\_ as SURETY, are  
held and firmly bound unto the DEPARTMENT OF TRANSPORTATION,  
Bureau of Highways, of the State of Tennessee to perform  
the work described in the Application and Utility Use and  
Occnpancy Agreement attached hereto and requested this the  
\_\_\_\_\_ day of \_\_\_\_\_, 19\_\_\_\_\_, in the  
manner prescribed in said Application and Agreement and to  
replace or repair any portion of pavement, shoulders, bridges  
or any other part of the highway described in said Agreement  
which may be damaged as a result of the work hereinbefore  
referred to. We do hereby agree to repair or replace any  
damaged portion of said highway in accordance with the  
Standard Specifications for Road and Bridge Construction of  
the Department of Transportation, Bureau of Highways, of the  
State of Tennessee. In the event such repairs or replace-  
ments are not made in a manner satisfactory to the Department  
of Transportation, Bureau of Highways, of the State of  
Tennessee, we hereby agree to reimburse said Department of  
the cost of such repairs.

## APPENDIX 1A(Cont.)

We do bind ourselves in the sum of \$ \_\_\_\_\_  
 for a term beginning the \_\_\_\_\_ day of \_\_\_\_\_,  
 19\_\_\_\_, until proper ease is received from the Department  
 of Transportation, Bureau of Highways, of the State of  
 Tennessee.

NOW, THEREFORE, the PRINCIPAL AND SURETY assume all  
 obligations and liabilities as set forth above.

SIGNED, SEALED and dated this the \_\_\_\_\_ day of  
 \_\_\_\_\_, 19\_\_\_\_.

\_\_\_\_\_  
 PRINCIPAL

BY \_\_\_\_\_

\_\_\_\_\_  
 TITLE

\_\_\_\_\_  
 SURETY

BY \_\_\_\_\_

Surety Company Bond No. \_\_\_\_\_

Mailing Address of Surety Company  
 \_\_\_\_\_  
 \_\_\_\_\_

Name and Address of Agency Writing Bond  
 \_\_\_\_\_  
 \_\_\_\_\_

(A copy of the Power of Attorney properly executed by the  
 company authorizing the Agent signing above to bind the  
 company as Surety on this Bond must be attached hereto.)

## APPENDIX I A(Cont.)

### R U N N I N G   S U R E T Y   B O N D

(For Utility Permits)

WHEREAS, it will be necessary, from time to time for \_\_\_\_\_ to locate utilities on and to perform work on State Highway rights of way within the \_\_\_\_\_ City \_\_\_\_\_ County (strike one) of \_\_\_\_\_, Tennessee, after applying for and being granted an Application and Utility Use and Occupancy Agreement with the Department of Transportation, Bureau of Highways, of the State of Tennessee for each such installation and,

WHEREAS, in consideration of the entering into Application and Utility Use and Occupancy Agreements by the Department of Transportation, Bureau of Highways, of the State of Tennessee, \_\_\_\_\_, agrees to insure to the said Department that it will repair or replace any portion of pavement, shoulders, bridges or any other part of any highway which may be damaged as a result of the work hereinbefore referred to,

NOW, THEREFORE, KNOW ALL MEN BY THESE PRESENTS:

That we, \_\_\_\_\_, as PRINCIPAL, and \_\_\_\_\_, as SURETY, are held and firmly bound unto the Department of Transportation, Bureau of Highways, of the State of Tennessee to perform any work within \_\_\_\_\_ City \_\_\_\_\_ County (strike one) of \_\_\_\_\_, Tennessee, permitted in any Application and Utility Use and Occupancy Agreement between \_\_\_\_\_ and the Department of Transportation, Bureau of Highways, of the State of Tennessee, applied for and granted after the \_\_\_\_\_ day of \_\_\_\_\_, 19\_\_\_\_, in the manner prescribed in each of said respective agreements and to replace or repair any portions of pavement, shoulders, bridges or any other part of the highway described in said respective agreements which may be damaged as a result of the work hereinbefore referred to. We do hereby agree to repair or replace the damaged portions of said highways in accordance with the Standard Specifications for Road and Bridge Construction of the Department of Transportation, Bureau of Highways, of the State of Tennessee. In the event such repairs or replacements are not made in a manner satisfactory to the Department of Transportation, Bureau of Highways, of the State of Tennessee, we hereby agree to reimburse the Department of Transportation, Bureau of Highways for the costs of such repairs.

We do bind ourselves in the sum of \$ \_\_\_\_\_ until proper release is received from the Department of \_\_\_\_\_

## APPENDIX 1A(Cont.)

Transportation, Bureau of Highways, of the State of Tennessee for each installation for which an Application and Utility Use and Occupancy Agreement was entered into between \_\_\_\_\_ and said Department from the date last above written until the termination of this Bond as provided for hereinafter. It is expressly understood and agreed that the above sum represents the total aggregate liability under this Bond on all work performed under Agreements issued as aforesaid but not properly released by said Department.

This Bond may be terminated by the SURETY following the giving of written notice of intention to terminate by certified mail to the Utilities Engineer, Department of Transportation, Bureau of Highways, of the State of Tennessee, Nashville, Tennessee, 37219, and said termination will become effective thirty (30) days after receipt of said notice. Proper termination notice notwithstanding, PRINCIPAL and SURETY will remain bound to the State of Tennessee under the terms hereinabove set out for the performance of any projects, with City (strike one) of \_\_\_\_\_, Tennessee, for which Application and Utility Use and Occupancy Agreements were entered into between the date last above written and said date of termination, until proper release is received from the Department of Transportation, Bureau of Highways, of the State of Tennessee for each of said projects.

NOW, THEREFORE, the PRINCIPAL and SURETY assume all obligations and liabilities as set forth above.

Signed, sealed and dated this \_\_\_\_\_ day of \_\_\_\_\_, 19\_\_\_\_.

Surety Company Bond No. _____	PRINCIPAL _____
Mailing Address of Surety Company _____	BY _____
_____	TITLE _____
Name and Address of Agency Writing Bond _____	SURETY _____
_____	BY _____
_____	

(A copy of the Power of Attorney properly executed by the company authorizing the agent signing above to bind the company as SURETY on this Bond must be attached hereto.)

# APPENDIX 2A

## INDIANA STATE HIGHWAY DEPARTMENT PERMIT FORM

State Form 41709

### State of Indiana Department of Highways PERMIT

Type of Permit:

☐ Cut Road      ☐ Pole Line      ☐ Bridge Attach.      ☐ Miscellaneous

District \_\_\_\_\_ Sub-District \_\_\_\_\_ Telephone (    ) \_\_\_\_\_

Project Location \_\_\_\_\_

Project Description \_\_\_\_\_

Project Purpose \_\_\_\_\_

Bond Required: ☐ Yes, Penal Sum \$ \_\_\_\_\_, Bond Number \_\_\_\_\_ ☐ No

PERMIT FEE: \$ \_\_\_\_\_ Check or Bank Draft Payable to "Indiana Department of Highways".

Special Provisions:

THE APPLICANT AGREES TO INDEMNIFY, DEFEND, EXCULPATE, AND HOLD HARMLESS THE STATE OF INDIANA, ITS OFFICIALS AND EMPLOYEES FROM ANY LIABILITY DUE TO LOSS, DAMAGE, INJURIES, OR OTHER CASUALTIES OF WHATSOEVER KIND, OR BY WHOMSOEVER CAUSED, TO THE PERSON OR PROPERTY OF ANYONE ON OR OFF THE RIGHT-OF-WAY ARISING OUT OF, OR RESULTING FROM THE ISSUANCE OF THIS PERMIT OR THE WORK CONNECTED THEREWITH, OR FROM THE INSTALLATION, EXISTENCE, USE, MAINTENANCE, CONDITION, REPAIRS, ALTERATION, OR REMOVAL OF ANY EQUIPMENT OR MATERIAL, WHETHER DUE IN WHOLE OR IN PART TO THE NEGLIGENT ACTS OR OMISSIONS (1) OF THE STATE, ITS OFFICIALS, AGENTS, OR EMPLOYEES; OR (2) OF THE APPLICANT, HIS AGENTS OR EMPLOYEES, OR OTHER PERSONS ENGAGED IN THE PERFORMANCE OF THE WORK, OR (3) THE JOINT NEGLIGENCE OF ANY OF THEM; INCLUDING ANY CLAIMS ARISING OUT OF THE WORKMEN'S COMPENSATION ACT OR ANY OTHER LAW, ORDINANCE, ORDER, OR DECREE. THE APPLICANT ALSO AGREES TO PAY ALL REASONABLE EXPENSES AND ATTORNEYS FEES INCURRED BY OR IMPOSED ON THE STATE IN CONNECTION HERewith IN THE EVENT THAT THE APPLICANT SHALL DEFAULT UNDER THE PROVISIONS OF THIS PARAGRAPH.

INSPECTOR \_\_\_\_\_

PERMIT APPLICANT SIGNATURE \_\_\_\_\_

DISTRICT PERMIT ENGINEER \_\_\_\_\_

NAME OF COMPANY OR ORGANIZATION \_\_\_\_\_

DISTRICT ENGINEER \_\_\_\_\_

POST OFFICE ADDRESS \_\_\_\_\_

(    )  
TELEPHONE \_\_\_\_\_

Personally appeared before me

as applicant this \_\_\_\_\_ day of \_\_\_\_\_, 19 \_\_\_\_\_

Witness my hand and \_\_\_\_\_ seal the said named date. My

Commission expires \_\_\_\_\_, 19 \_\_\_\_\_

NOTARY SIGNATURE \_\_\_\_\_

NOTARY PRINTED \_\_\_\_\_

5 Copies — Submit all copies

White — Division of Maintenance

Green — Surety

Canary — Sub-District

Pink — Applicant

Gold — District

APPLICATION NUMBER

ROAD NUMBER

SECTION

EXPIRATION DATE

ISSUE DATE

PERMIT NUMBER

## APPENDIX 2A(Cont.)

### State of Indiana Department of Highways GENERAL PROVISIONS

1. All work described in the permit shall be subject to the inspection of the Department of Highways and the permittee shall adjust or stop operations upon direction of any police officer or authorized Department of Highways employee.
2. The permit may be revoked at any time by the Department of Highways for non-compliance with any and/or all provisions of said permit.
3. The permittee shall notify the Department of Highways Sub-District five (5) working days preceding the beginning of any work activity.
4. The permittee shall notify the Department of Highways Sub-District that the work is complete and this notice is to be provided within seven (7) days from completion of all work on this permit.
5. The permittee shall have the permit complete with drawings and special provisions in their possession during work operations and will show said permit, on demand, to any police officer or authorized Department of Highways employee.
6. The permittee shall pay the Department of Highways for any inspection costs where it is necessary to assign a Department of Highways employee to inspect the work. The applicant shall immediately reimburse the State upon receipt of an itemized statement.
7. The permit is valid through the stated expiration date. If work is not completed within the allotted time, the permit is automatically cancelled unless an extension is requested prior to the expiration date and said request is approved by the Department of Highways. If a permit is cancelled, a new application must be submitted and approved before the proposed work can be accomplished.
8. The permittee shall erect and maintain all necessary signs, barricades, detour signs, and warning devices required to safely direct traffic over or around the part of the highway where permitted operations are to be done so long as the work does not interfere with traffic, in accordance with Section "D" of the Indiana Manual of Uniform Traffic Control Devices.
9. All construction and materials used within the highway right-of-way must conform to the current Department of Highways "Standard Specifications" with the permittee being considered in the same status as the contractor.
10. Any operations authorized by the permit shall not interfere with any existing structure on the Department of Highways right-of-way without specific permission in writing from the Department of Highways. In the event that any buildings, railings, traffic control devices, or other structures are damaged, said cost of the removal and/or damage shall be borne by the permittee.
11. This permit does not apply to any State roads or bridges that are closed for construction purposes, or to any county roads or city streets.
12. Approval of the permit application shall be subject to the permittee obtaining all necessary authorizations from local authorities and complying with all applicable laws. The issuance of the permit shall in no way imply Department of Highways approval of, or be intended to influence any action pending before a local board, commission, or agency.
13. The permitted operations shall not be performed on Saturdays, Sundays, or during the period beginning at 12:00 Noon on the last weekday (Monday through Friday) preceding and continuing until Sunrise on the day following: New Years Day, Memorial Day, Independence Day, Labor Day, Thanksgiving, and Christmas.
14. In accordance with the notice requirements of Indiana Code 4-22-1-25, any objection to the conditions and provisions of an approved permit must be submitted in writing to the Department of Highways within fifteen (15) days from the issue date.

# APPENDIX 3A

## INDIANA STATE HIGHWAY DEPARTMENT INSPECTION FORM

State Form 41820

State of Indiana  
Department of Highways

### PERMIT INSPECTION REPORT AND COST SUMMARY

Type of Permit:

☐ Oversize    ☐ Overweight    ☐ Driveway    ☐ Cut Road    ☐ Pole Line    ☐ Bridge Attachment    ☐ Misc.

District \_\_\_\_\_ Sub-District \_\_\_\_\_

 To: Chief, Division of Maintenance  
and Engineer of Permits

This is to inform you the work in the referenced permit has been thoroughly inspected and found to be as checked in the box below.

Date of Inspection: \_\_\_\_\_

☐ **COMPLIES** — (The work has been completed according to all provisions outlined in the permit and final approval is granted.)

Explain: \_\_\_\_\_

Release Surety on Bond Number: \_\_\_\_\_

☐ **DOES NOT COMPLY** — (The applicant has been informed to make the following corrections to comply with the permit provisions.)

Explain: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Notify Surety on Bond Number: \_\_\_\_\_

☐ **CANCEL** — Explain: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Release Surety on Bond Number: \_\_\_\_\_

INSPECTOR \_\_\_\_\_

Name of Applicant \_\_\_\_\_

DISTRICT ENGINEER \_\_\_\_\_

Address \_\_\_\_\_

5 Copies

White — Division of Maintenance

Green — Surety

Canary — Sub-District

Pink — Applicant

Gold — District

☐ No inspection costs are to be charged.

☐ Inspection costs are shown on reverse side of this report.

APPLICATION NUMBER

ROAD NUMBER

SECTION

COMPLIANCE DATE

ISSUE DATE

PERMIT NUMBER

## APPENDIX 3A(Cont.)

The following is an itemized cost summary for services performed on the referenced permit.

## STATE EMPLOYEE

<u>Date</u>	<u>Hours</u>	<u>Hourly Rate</u>	<u>Labor</u>	<u>Overhead</u>	<u>Amount</u>
-------------	--------------	--------------------	--------------	-----------------	---------------

Sub-Total: \_\_\_\_\_

## VEHICLE

<u>Date</u>	<u>Miles</u>	<u>Rate</u>	<u>Amount</u>
-------------	--------------	-------------	---------------

Sub-Total: \_\_\_\_\_

## OTHER

<u>Date</u>	<u>Unit</u>	<u>Number of Units</u>	<u>Rate</u>	<u>Amount</u>
-------------	-------------	------------------------	-------------	---------------

Sub-Total: \_\_\_\_\_

Total: \_\_\_\_\_



## APPENDIX 4A

### INDIANA STATE HIGHWAY DEPARTMENT PERMIT REVIEW TIME TABLE

#### CUT ROAD (Major)

##### Step

1. All applications are initially received at the District Office over the counter or by mail. The District is to verify all pertinent existing field conditions as described by the application and shown on the plans. The application package is reviewed for completeness and compliance with standards. It is forwarded to the Permit Department with recommendations.  
(5WD)

2. The Permit Department is to initially perform a preliminary review of the application for completeness and compliance with standards.  
(2WD)

3A. The Permit Department forwards by memorandum to the Traffic Division the following information:  
(3WD)

- a) Permit Form (SF 41769)
- b) Plans
- c) Traffic control plans
- d) Means and sequence of performing work
- e) Copy of memorandum from the District

The Traffic Division is to review all information provided related to but not limited to:

- a) Traffic Control at the time of work activity
- b) Effects on State Highway traffic equipment
- c) Conflicts with future traffic construction projects
- d) Recommend unique special provisions

The Traffic Division is to forward their recommendations either by note on the Permit Department memorandum for minor comments or by separate memorandum for more complicated responses to the Permit Department.

3B. The Permit Department forwards by memorandum to the Utilities-Railroad Section the following information:  
(3.5WD)

- a) Permit Form (SF 41769)
- b) Plans
- c) Letter of explanation from the applicant
- d) Copy of memorandum from the District

The Utilities - Railroad Section is to review all information provided related to but not limited to:

- a) Compliance with standards for utility occupancy of State Highway right-of-way.
- b) Acceptable construction methods for utility work on right-of-way.
- c) Effects on State Highway facilities in work area.
- d) Recommend unique special provisions.

The Utilities - Railroad Section is to forward their recommendations either by note on the Permit Department memorandum for minor comments or by separate memorandum for more complicated responses to the Permit Department.

## APPENDIX 4A(Cont.)

- 2 -

3C. If the permit application involves grading and/or drainage work that will affect the State Highway right-of-way, the Permit Department forwards by memorandum to Road Design the following information:

(7WD)

- a) Permit Form (SF 41769)
- b) Drainage including all drainage structures and calculations
- c) Grading site plans

Road Design is to review all information provided related to but not limited to:

- a) Effects of work site activity on drainage, erosion control, etc.
- b) Restoration of vegetation and fences
- c) Review miscellaneous items such as curbs, sidewalks, etc.
- d) Recommend unique special provisions

Road Design is to forward their recommendations either by note on the Permit Department memorandum for minor comments or by separate memorandum for more complicated responses to the Permit Department.

4. The Permit Department collects and coordinates all Departments and District findings. A memorandum to the Assistant Chief, Division of Maintenance is prepared and forwarded containing the combined recommendations, the permit application form, the special provisions, the plans, and other information.

(2WD)

5. The Assistant Chief, Division of Maintenance makes a final determination and the memorandum with instructions noted is returned to the Permit Department for final processing. If the permit is approved, the Assistant Chief signs the permit form.

(2WD)

6A. Approved permits are assigned a permit number, start date, expiration date, and special provisions are attached. The Permit Department distributes the copies of the issued permit to the District, the applicant, the Surety, and to file.

(2WD)

6B. Disapproved permits are assigned a denial number. A letter to the applicant with copies to the Surety and District is prepared for the Assistant Chief, Division of Maintenance signature. The letter states that the permit application is disapproved and the reason(s) for the denial.

(2WD)

Total:  
(16.5 WD)  
(20 WD for grading and drainage permit)

Excluding Mail time

APPENDIX 5A  
INDIANA STATE HIGHWAY DEPARTMENT  
PRELIMINARY APPLICATION FOR EMERGENCY CUTS

PRELIMINARY APPLICATION FOR EMERGENCY CUTS ONLY\*

Cuts to be made in (State Highways or State Routes) (in outside) Cities by Utilities.

Date Work Started .....

Address .....

This is an emergency cut because. ....

.....

Regular Application Form M-173 and check will be filed at State Highway Sub-

District Office not later than .....

Name of Utility .....

By ..... Phone No. ....

Address .....

\*Emergency cuts are defined as these to repair leaks or any other work that has to be done immediately to protect life or property.

Date .....

Verbal permission given by .....

Time .....

## APPENDIX B

## APPENDIX 1B

## SAND CONE CALCULATION

Sand Cone Sample calculation: A sand cone holds 850.0g.  
 The loose density of the sand is  $1.425 \text{ g/cm}^3$ . The Max.  
 Proctor value for this material is  $1.80 \text{ g/cm}^3$

## Field Test Results:

Total weight of soil	640.0g
Dry weight of soil	545.3g
Initial weight of sand cone	4520.0g
Final weight of sand cone	3220.4g

## Calculations:

Mass of sand used  $4520.0\text{g} - 3220.4\text{g} = 1299.6\text{g}$

Mass in test hole  $1299.6\text{g} - 850.0\text{g} = 449.6\text{g}$

Volume of test hole  $\frac{449.6\text{g}}{1.425\text{g/cm}^3} = 315.5 \text{ cm}^3$

Field dry density  $\frac{545.3\text{g}}{315.5 \text{ cm}^3} = 1.728 \text{ g/cm}^3$

Field water content  $\frac{640.0\text{g} - 545.3\text{g}}{545.3\text{g}} = 17.4\%$

Relative Compaction:  $\text{R.C.} = \frac{1.728\text{g/cm}^3}{1.80 \text{ g/cm}^3} \times 100(\%) = 96.0\%$

## APPENDIX 2B

## BALLOON DENSOMETER CALCULATION

## Balloon Densometer

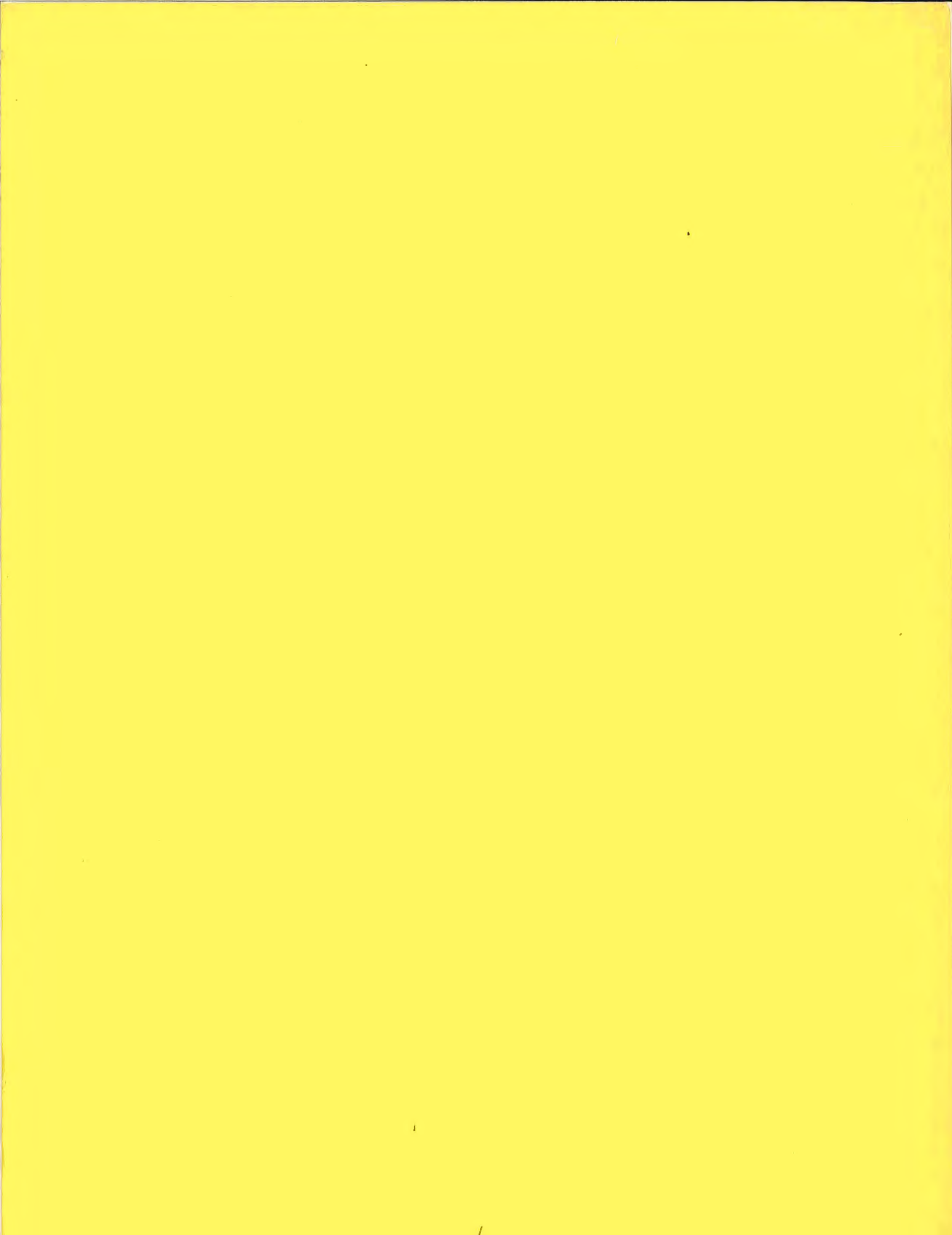
Maximum Proctor Value of the tested material is  
 $2.075 \text{ g/cm}^3$ .

Data:	Mass of the sample from the test hole	450.0g
	Dry mass	405g
	Volume of the test hole	$202.3 \text{ cm}^3$

Field dry density:  $\frac{405 \text{ g}}{202.3 \text{ cm}^3} = 2.002 \text{ g/cm}^3$

Water content:  $\frac{450.0 \text{ g} - 405.0 \text{ g}}{405.0 \text{ g}} = 11.1\%$

Relative Compaction (R.C.) =  $\frac{2.002 \text{ g/cm}^3}{2.075 \text{ g/cm}^3} \times 100(\%) = 96.5\%$



K.B.  
Street Cuts in City and County Streets  
H-83-5